California Instruments
A Norlin Technology Company

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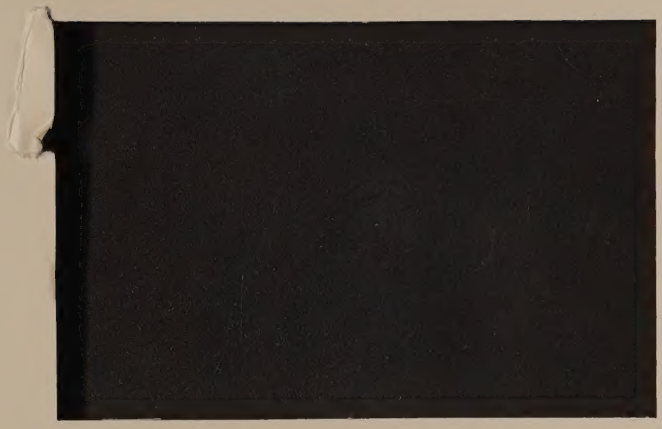
MANUAL # 7



California Instruments

A Norlin Technology Company

Revision C
March, 1978

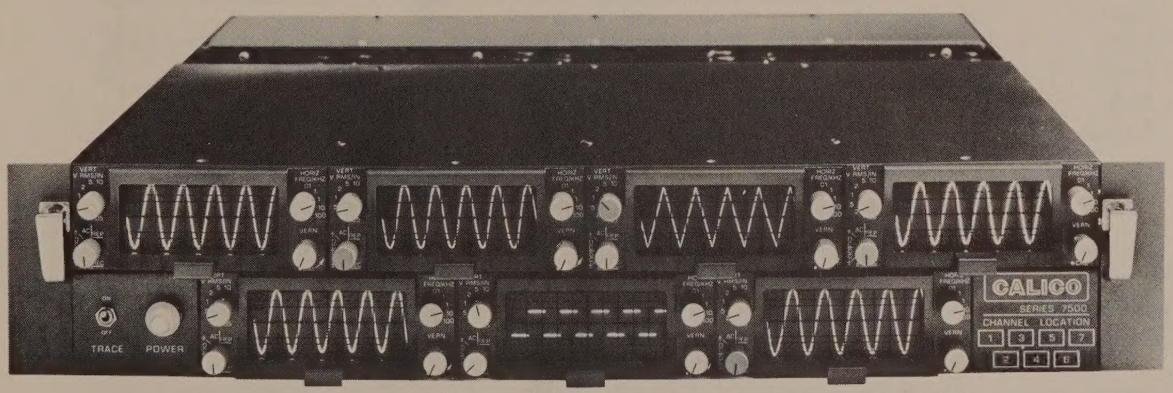
TECHNICAL MANUAL

INSTRUCTIONS AND PARTS BREAKDOWN

MODEL 7500
7800LK-939
SEVEN CHANNEL

MONITOR

OSCILLOSCOPE



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Assembly Reference Designator	Drawing Number	
A1	E7510-070-1	Module Schematic
A1	E7510-700-2	Module Assembly
None	E7520-400-2	Rack Adapter/Power Supply Assembly
A2	E7520-070-1	Innerconnection Schematic
A2	D7520-700-2	Innerconnect Board Rack and Power Supply
A3	D7520-071-1	High Voltage Power Supply Schematic
A3	C7520-701-2	High Voltage Board Assembly
A4	D7520-072-1	Low Voltage Power Supply Schematic
A4	C7520-702-2	Low Voltage Board Assembly
None	C7520-900-1	Rack Adapter/Power Supply Outline Drawing
None	C7520-900-2	Module Outline Drawing

July 2, 1974

MANUAL ADDENDUM
MODEL 7500LK-939 MONITOR OSCILLOSCOPE SYSTEM

1.0 GENERAL

The California Instruments Model 7500LK-939 Monitor Oscilloscope System is identical to the standard Model 7500 Monitor Oscilloscope System except that the sweep rate of the Model 7513 M-LK Module has been reduced by a factor of 10 to 1 on all sweep ranges. Also, module locks have been added to each module and to the rack adapter/power supply.

The Model 7500LK-939 Oscilloscope System emplovs the standard "tape recorder" nomenclature, ie., vertical deflection in volts rms per inch (four major divisions) and horizontal time base in frequency to display a single cycle of a sine wave across the 10 major horizontal divisions. The Model 7500LK-939 Oscilloscope system provides a sweep rate equal to one-tenth of that in the standard Model 7500 Monitor Oscilloscope System.

2.0 SPECIFICATIONS

All performance specifications for the Model 7500LK-939 Oscilloscope System are listed below.

PARAMETER	SPECIFICATIONS/PERFORMANCE
Vertical Amplifier Characteristics:	
Bandwidth:	DC to 5 MHz ±1.0 dB. DC to 10 MHz ±3.0 dB.
Sensitivity:	0.05 volts to 10 volts rms per inch in eight calibrated steps arranged in a 1, 2, 5 sequence.
Accuracy:	±3 per cent of full scale on all ranges.
Input Impedance:	1 megohm in parallel with 100 pf (typical) on all ranges.
DC Offset Drift:	Less than 2 per cent of full scale upon application of power. No detectable drift after five minutes warm-up over the 0 to 55°C temperature range.
Transient Response:	40 nanoseconds maximum rise time from 0 to 90 per cent of final value on all ranges.

PARAMETER	SPECIFICATIONS/PERFORMANCE
Input Mode Coupling:	Six position front panel rotary switch selects one to two data inputs in either AC or DC coupling mode. Fifth and sixth position disconnects input signal and then grounds the input to the vertical amplifier.
Isolation:	Signal and external trigger input BNC connectors are isolated and floating from rack adapter and power line ground be greater than 10,000 megohms. Strap on interconnect board allows low side of signals to be grounded or floating.
Horizontal Sweep Characteristics:	
Sweep Rate:	1 Hz to 10 KHz in five calibrated decade steps with a X 10 vernier control to provide a maximum sweep frequency of 100 KHz or greater.
Sweep Accuracy:	±3 per cent of full scale.
Sweep Linearity:	±3 per cent of full scale.
Trigger Mode:	Selectable internal or external: automatic triggering from 1 Hz to 1 MHz.
Trigger Slope Polarity:	Either positive or negative polarity triggering in either an internal or external mode.
Trigger Level: (with sine wave trigger over 1 Hz to 1 MHz range)	0.5 inch peak-to-peak deflection with internal trigger. 1.0 volt peak-to-peak from 1.0 Hz to 1.0 MHz with external trigger.
Model 7513 M-LK Module Controls:	
Front Panel:	Vertical sensitivity selector switch; REC-REP and input mode coupling; Horizontal sweep rate selector switch; X 10 sweep vernier control.
Rear of Module:	Vertical position control; Horizontal position control; Trigger polarity switch; Internal/External trigger switch; Focus control; Intensity control; Trace angle alignment control.

PARAMETER	SPECIFICATIONS/PERFORMANCE
General Characteristics:	
Cathode Ray Tube:	1 inch by 3 inch CRT with flat face.
Phosphor:	EIA type P31.
Graticule:	4 vertical and 10 horizontal one-quarter inch major divisions. Each major division is further divided into five minor divisions. Reference level indicator 3 dB below full scale is provided. Graticule is green in color.
CRT Anode Voltage:	2050 volts DC.
Operating Ambient Temperature Range:	0 to 55°C.
Storage Temperature Range:	-20°C to 85°C.
Power Requirements:	105 to 125 volts AC, 48 to 420 Hz or 210 to 250 volts AC, as determined by interconnect board strapping. Units are shipped for 105 to 125 volts AC operation, unless otherwise specified.
Dimensions:	3-1/2 inches high x 17 inches wide x 20.7 inches deep with 2" Zero Mfg. Co. rack slides for mounting in a standard 19 inch rack.
Net Weight:	40 pounds.
Shipping Weight:	50 pounds.
Paint:	a) Metallic Charcoal Grey Cardinal 5004-1210 with white silk screening or b) Grey, 26440 per Federal Standard 595 with black silk screening 37038 available on request at time of order.

3.0 FRONT PANEL CONTROLS

Front panel controls for the Model 7513M-LK Module are silk-screened in terms of volts rms per inch and Kilohertz displayed per sweep.

4.0 REAR PORCH CONTROLS

Rear Porch controls for the Model 7513M-LK Module are identical to the rear porch controls for the standard Model 7500 Monitor Oscilloscope System.

5.0 THEORY OF OPERATION

The theory of operation for the 7500LK-939 Oscilloscope System is identical to that for the Model 7500 except that the constant current source A1Q2 delivers 10 microamperes to the integrating capacitor, one of A1C46 through A1C50 rather than 100 microamperes as in the Model 7500.

An isolation amplifier, consisting of A1Q14 and associated components, has been added to each module in the Model 7500LK-939 Oscilloscope System to sense the voltage across the integrating capacitor. This reduces the loading on the integrating capacitor and there by improves the linearity of the sweep generator with low values of integrating current.

6.0 ADJUSTMENT PROCEDURE

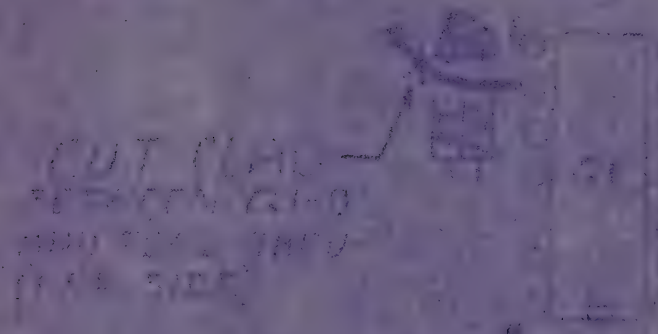
The Model 7513M-LK Module is adjusted identically to the standard Model 7510 Oscilloscope Module except that the horizontal sweep rate is one-tenth of the standard oscilloscope module. The free running rate of the trigger generator A1Q4 is approximately 5 Hz to 7 Hz rather than 50 Hz to 75 Hz as in the standard oscilloscope module. The hold-off time is also somewhat greater than in the standard oscilloscope module.

The Model 7520-LK Rack Adapter/Power Supply adjustments are identical to those called out in section 5-17 through 5-23 of the standard Model 7500 instruction manual.

7.0 PARTS LIST

The parts list for the Model 7500LK-939 Oscilloscope System is identical to that for the standard Model 7500 as modified by addendum parts list 7510-404 for the Model 7513M-LK Module.

ADD #24 GA HIGH VOLTAGE WIRES
ON CLAD SIDE OF BOARD:
FROM A1-63 TO PIN 5
FROM A1-60 TO PIN 3



REGISTER ABOVE		ITEM NO	PART NUMBER	

MATERIAL - SPECIFICATION
MASTER
13M
CALCO

CALICO — CALIFORNIA INSTRUMENTS CO. SAN DIEGO, CALIFORNIA — CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
	7510-700-1	SCOPE MODULE "7510"		FIN. GDS.	1
					2
ADD TO STD. 7510 OSCILLOSCOPE MODULE					3
					4
					5
	C7510-209-5	FRONT PANEL	16067	1-10328	6
					7
C11	T360C226M025AS	CAPACITOR 22µF 25V	05397	6-10746	8
C14	T360D226M010AS	CAPACITOR 220µF 10V	05397	6-10766	9
C20	T360D226M010AS	CAPACITOR 220µF 10V	05397	6-10766	10
C24	T360D226M010AS	CAPACITOR 220µF 10V	05397	6-10766	11
C32	CM05F331J03	CAPACITOR 330PF 500V	81349	6-10042	12
C37	7D5A473K	CAPACITOR .047µF 50V	12406	6-10115	13
C38	T360A224M050AS	CAPACITOR .22µF 50V	05397	6-10808	14
C39	T360A474M050AS	CAPACITOR .47µF 50V	05397	6-10781	15
C40	T360A225M025AS	CAPACITOR 2.2µF 25V	05397	6-10798	16
C50	CM05ED470J03	CAPACITOR 47PF 500V	81349	6-10268	17
C51	CM05F101J03	CAPACITOR 100PF 500V	81349	6-10027	18
C42	T360C685M050AS	CAPACITOR 6.8µF 50V	05397	6-10752	19
C41	T360B106M025AS	CAPACITOR 10µF 25V	05397	6-10733	20
					21
R15	RC07GF203J	RESISTOR 20K 1/4W 5%	81349	5-10083	22
R16	WA2G050S-204UA	POTENTIOMETER 200K	01121	5-10187	23
R53	RC07GF620J	RESISTOR 620Ω 1/4W 5%	81349	5-10043	24
R36	RC07GF912J	RESISTOR 9.1K 1/4W 5%	81349	5-10075	25
R72	RC07GF621J	RESISTOR 620Ω 1/4W 5%	81349	5-10043	26
R114	RC07GF103J	RESISTOR 10K 1/4W 5%	81349	5-10070	27
CR10	1N5224	DIODE ZENER	81349	6-10263	28
					29
Q14	U1899E	TRANSISTOR F.E.T.	15818	8-30190	30
					31
IC1	SN7402N	INTEGRATED CIRCUIT	27014	3-00001	32
IC2	SN7402N	INTEGRATED CIRCUIT	27014	3-00001	33
					34
					35
					36

MODEL	CALICO P/N	ASSY R.D.
7513M	7513-101	A

TITLE	SHT	OF
MASTER SCOPE MODULE	2	4

CALICO — CALIFORNIA INSTRUMENTS CO. SAN DIEGO CALIFORNIA — CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
					1
					2
DELETE FROM STD. 7510 OSCILLOSCOPE MODULE					3
					4
					5
	C7510-209-1	FRONT PANEL ASSY.	16067	1-10230	6
					7
C11	2C02347X0250A3	CAPACITOR .47μF 25V	56289	6-10790	8
C14	T360B476M006AS	CAPACITOR 47μF 6V	05397	6-10775	9
C20	T360B476M006AS	CAPACITOR 47μF 6V	05397	6-10775	10
C24	T360B336M010AS	CAPACITOR 33μF 10V	05397	6-10751	11
C32	CM05ED390J03	CAPACITOR 39PF 500V	81349	6-10013	12
					13
C38	192P22392	CAPACITOR .022μF 200V	56289	6-10784	14
C39	225P47391	CAPACITOR .047μF 100V	56289	6-10572	15
C40	T360A474M050AS	CAPACITOR .47μF 50V	05397	6-10781	16
C42	TG-S10	CAPACITOR .01μF 100V	56289	6-10759	17
C41	T360A475M010AS	CAPACITOR 4.7μF 10V	05397	6-10750	18
C60	DM10-020D	CAPACITOR 2pF 500V	72136	6-10001	19
C63	TG-S10	CAPACITOR .01μF 100V	56289	6-10759	20
C37	6DP-1-472	CAPACITOR .0047μF 100V	72136	6-10547	21
R15	RC07GF202J	RESISTOR 2K 1/4W 5%	81349	5-10059	22
R16	WA2G050S-203UA	POTENTIOMETER 20K	01121	5-70140	23
					24
R35	RC07GF103J	RESISTOR 10K 1/4W 5%	81349	5-10076	25
R53	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	26
R72	RC07GF241J	RESISTOR 240Ω 1/4W 5%	81349	5-10038	27
					28
IC1	SN74LS02N	INTEGRATED CIRCUIT	07263	3-60157	29
IC2	SN74S02N	INTEGRATED CIRCUIT	07263	3-60231	30
					31
					32
					33
					34
					35
					36

MODEL 7513M — CALICO P N 7510-401 — ASSY R.D.

TITLE MASTER SCOPE MODULE — SHT 3 OF 4

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SECTION I

GENERAL INFORMATION

1-1 INTRODUCTION

1-2 This technical manual contains physical and functional descriptions, theory of operation, operating and maintenance instructions (including component location and schematic diagram), and a list of replaceable parts for the Model 7500 Monitor Oscilloscope. A photograph of the complete monitor oscilloscope is shown in the frontispiece and is manufactured by CALIFORNIA INSTRUMENTS COMPANY, a division of AIKEN INDUSTRIES.

1-3 PHYSICAL DESCRIPTION

1-4 The Model 7500 Monitor Oscilloscope is a rack mountable seven channel monitor oscilloscope system which utlizes modular packaging and complete plug-in construction. The system is split into two parts. These are:

a) Model 7520 Rack Adapter/Power Supply.

b) Model 7510 Plug-in Oscilloscope Modules (7 each).

1-5 SPECIFICATIONS AND PERFORMANCE DATA

1-6 Specifications and performance data of the Model 7500 Monitor Oscilloscope System are listed in table 1-1 below. All specifications are tested in accordance of standard CALICO test procedures as given in section V of this Instruction manual.

Table 1-1. Specifications and Performance Data.

PARAMETER	SPECIFICATIONS/PERFORMANCE
Vertical Amplifier Characteristics:	
Bandwidth:	dc to 5 MHz ±1.0 db dc to 10 MHz ±3.0 db
Sensitivity:	0.05 volts to 10 volts rms per inch in eight calibrated steps arranged in a 1, 2, 5 sequence.
Accuracy:	±3 per cent of full scale on all ranges
Input Inpedance:	1 megohm in parallel with 100 pf (typical) on all ranges
DC Offset Drift:	Less than 2 per cent of full scale upon application of power. No detectable drift after five minutes warm-up over the 0 to 55°C temperature range.

Table 1-1. Specifications and Performance Data (continued).

PARAMETER	SPECIFICATIONS/PERFORMANCE
Transient Response:	40 nanoseconds maximum rise time from 0 to 90 percent of final value on all ranges.
Input Mode Coupling:	Six position front panel rotary switch selects one of two data inputs in either ac or dc coupling mode. Fifth and sixth position disconnects input signal and then grounds the input to the vertical amplifier.
Isolation:	Signal and external trigger input BNC connectors are isolated and floating from rack adapter and power line ground by greater than 10,000 megohms. Strap on innerconnect board allows low side of signals to be grounded or floating.
Horizontal Sweep Characteristics:	
Sweep Rate:	10 Hz to 100 KHz in five calibrated decade steps with a x 10 vernier control to provide a maximum sweep frequency of 1 MHz or greater.
Sweep accuracy:	±3 per cent of full scale
Sweep Linearity:	±3 per cent of full scale
Trigger Mode:	Selectable internal or external; automatic triggering from 10 Hz to 10 MHz.
Trigger Slope Polarity:	Either positive or negative polarity triggering in either an internal or external mode.
Trigger Level:	0.1 inch peak to peak deflection with internal trigger. 0.15 volt peak-to-peak from 50 Hz to 5 MHz with external trigger. 0.5 volt peak-to-peak from 10 Hz to 10 MHz with external trigger.
Controls:	
Front Panel:	Vertical sensitivity selector switch; REC-REP and input mode coupling; Horizontal sweep rate selector switch; x 10 sweep vernier control.

Table 1-1 Specifications and Performance Data (continued).

PARAMETER	SPECIFICATIONS/PERFORMANCE
Rear of Module:	Vertical position control; Horizontal position control; Trigger polarity switch; Internal/External trigger switch; Focus control; Intensity control; Trace angle alignment control.
General Characteristics:	
Cathode Ray tube:	1 inch by 3 inch CRT with flat face
Phosphor:	P31 standard. Other types availiable on special order.
Graticule:	4 vertical and 10 horizontal one-quarter inch major divisions. Each major division is further divided into five minor divisions. Reference level indicator 3db below full scale is provided. Graticule is green in color.
CRT Anode Voltage:	2050 volts dc
Operating Ambient Temperature Range:	0 to 55°C
Storage Temperature Range:	-20°C to 85°C
Power Requirements:	105 to 125 volts ac, 48 to 420 Hz, or 210 to 250 volts ac, as determined by innerconnect board strapping. Units are shipped for 105 to 125 volts ac operation, unless otherwise specified.
Dimensions:	3 1/2 inches high x 17 inches wide x 20.7 inches deep with 2" Zero Mfg Co. rack slides for mounting in a standard 19 inch rack.
Net Weight:	40 pounds
Shipping Weight:	50 pounds
Paint:	a) Metallic Charcoal Grey Cardinal 5004-1210 with white silk screening or b) Grey, 26440 per Federal Standard 595 with black silk screening 37038 available on request at time of order.

1-7 EQUIPMENT SUPPLIED

1-8 Normally an instruction manual and mounting brackets for a standard 19 inch rack are supplied with the Model 7500 Monitor Oscilloscope System.

1-9 EQUIPMENT REQUIRED BUT NOT SUPPLIED

1-10 Table 1-2 lists equipment required for calibration and maintenance of the Model 7500 Monitor Oscilliscope System as defined in this publication, but which is not supplied as part of the equipment.

1-11 ACCESSORIES AVAILABLE

1-12 The following accessories are available, but not normally supplied, from California Instruments Company for use with the Model 7500 Monitor Oscilloscope System.

a) Module extender assembly; part number 7510-701. This card allows the oscilloscope module to be extended out beyond the rack adapter/power supply for maintenance of monitor oscilloscope module.

b) Blank panel assembly: part number 7510-801. This assembly is used to fill the slot left in monitor oscilloscope systems which do not have a full complement of seven modules. One blank panel assembly should be ordered for each vacant oscilloscope module slot.

c) Rear cable retractor assembly: part number 7520-401. This assembly extends and withdraws the rear cables to the monitor oscilloscope as it is pulled back and forth along its slide rails.

d) Power supply load plug in assembly: part number 7520-402. This plug in module simulates the load of seven oscilloscope modules and is useful in adjusting the power supply if oscilloscope modules are not available for use as a load. All power supply voltages are conveniently available at the front of this plug in assembly.

e) Module lock; option LK. This module lock allows each oscilloscope module to be locked into position by means of seven retainer clips mounted on the rack adatper/power supply which secures the oscilloscope modules in position.

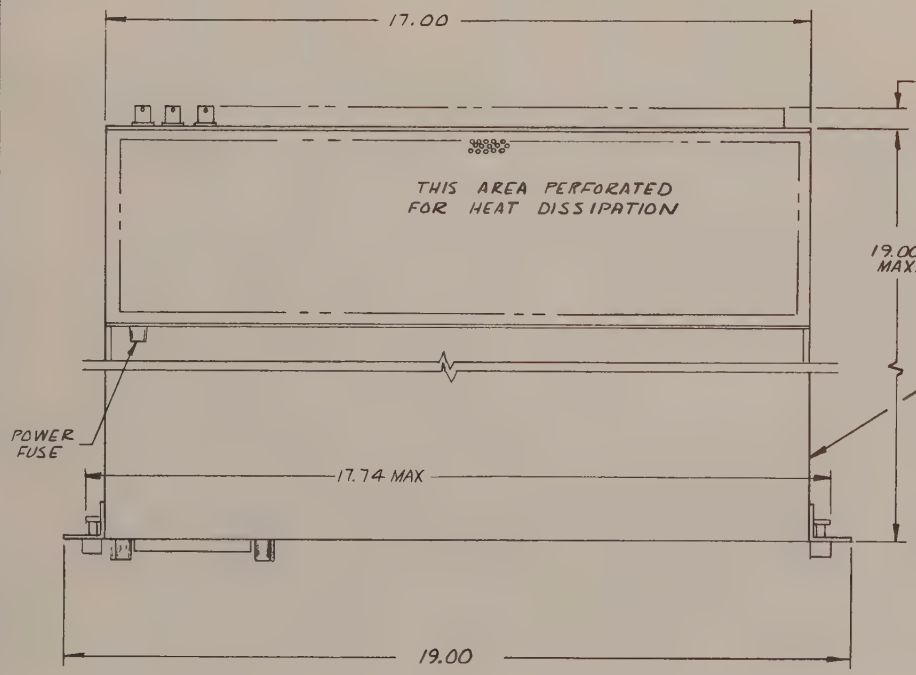
1-13 ONE YEAR WARRANTY

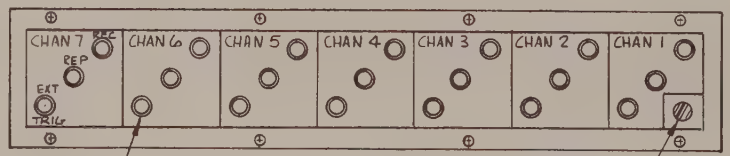
1-14 CALIFORNIA INSTRUMENTS COMPANY warrants each instrument manufactured by them to free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS COMPANY will service, replace, or adjust any defective part or parts free of charge, when the instrument is returned to the Company, freight prepaid, and when examination reveals that fault has not occurred because of misuse or abnormal conditions of operation. Equipment repaired beyond the effective date of warranty, or when abnormal usage has occurred, will be charged at applicable rates. CALICO will submit an estimate for such charges before commencing repair if so requested.

Table 1-2. Equipment Required But Not Supplied.

QUANTITY	EQUIPMENT	MODEL	USAGE
1	Variac	Superior Electric Model 216 or equivalent.	Power supply test and adjustment.
1	Wattmeter	Triplett Model 661 or equivalent.	AC power input measurment.
1	Oscilloscope	Tektronix Model 545B with type L plug-in and x 10 probe or equivalent.	Repair and adjustment of module and power supply.
1	Digital Voltmeter	Calico Model 8420 with Model 8450 High Voltage Probe or equivalent.	Power supply test and adjustment.
1	AC Voltmeter	Hewlett Packard Model 400H or equivalent.	Vertical amplifier frequency response adjustment.
1	Multimeter	Triplett 630NA or equivalent.	Floating power supply voltage measurements.
1	Sine Wave Generator	Hewlett Packard Model 651A or equivalent.	Vertical amplifier frequency response adjustment.
1	Square Wave Generator	Hewlett Packard Model 211A or equivalent.	Vertical attenuator adjustment.
1	Pulse Generator	Data Pulse Model 101 or equivalent.	Rise time test of vertical amplifier and attenuator.
2	50 ohm Termination units	Tektronix 011-0049 01 or equivalent.	Rise time test of vertical amplifier and attenuator.
1	Constant Amplitude Signal Generator	Tektronix Model 190B or equivalent.	Vertical amplifier calibration and adjustment.
1	Electronic Counter	Hewlett Packard Model 523CR or equivalent.	Calibration and adjustment of linear sweep.
1	Battary	1.5 volt dry cell Eveready No. 1050 or equivalent.	Input mode switch test.
1	Humiseal 1B15	Columbia Technical Corporation Woodside, N.Y.	Repair of high voltage power supply or high volt- section of oscilloscope module.

REVISIONS						
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD
A	DC.	ADDED 17.74 DIM.			4-22-71	JR

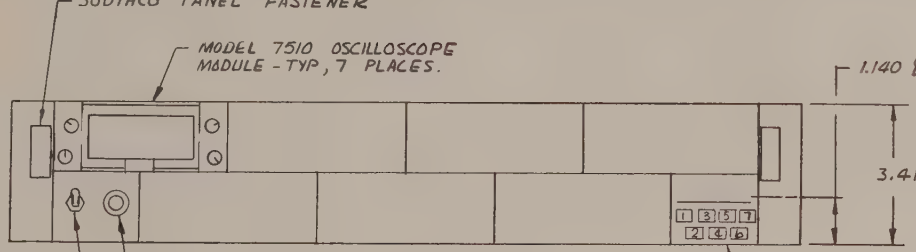




UG1094A/U COAXIAL CONN. TYP - 21 PLACES

6' PWR CORD WITH 3 PRONG PLUG

REAR VIEW



FRONT VIEW

1. SEE SHEET 2 FOR MODULE OUTLINE.

NOTES: (UNLESS OTHERWISE SPECIFIED)

REQD PER ASSY	ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE

DIM IN INCHES TOLERANCES .XXX = .010 .XX = .03 X° = 30'

BREAK ALL SHARP CORNERS & EDGES MACH SURFACES

DWG SIZE C

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TITLE: OUTLINE DWG, MODEL 7500 OSCILLOSCOPE SYSTEM

MODEL 7500

RELEASE		3/19/71	
CHECKER		3/15/71	PURCHASING
DESIGN			PROJ ENGR
DRFTSMN	MARTINM	2-2-71	CHF ENGR

DASH NO.	QTY REQD	NEXT ASSEMBLY	EFF ON	AUTH

CALICO
CALIFORNIA INSTRUMENTS CORP.
SAN DIEGO, CALIFORNIA

CONTRACT NO.

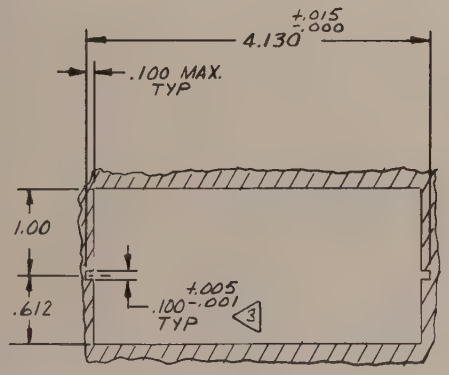
CODE IDENT 16067

DWG NO. C7520-900 REV A

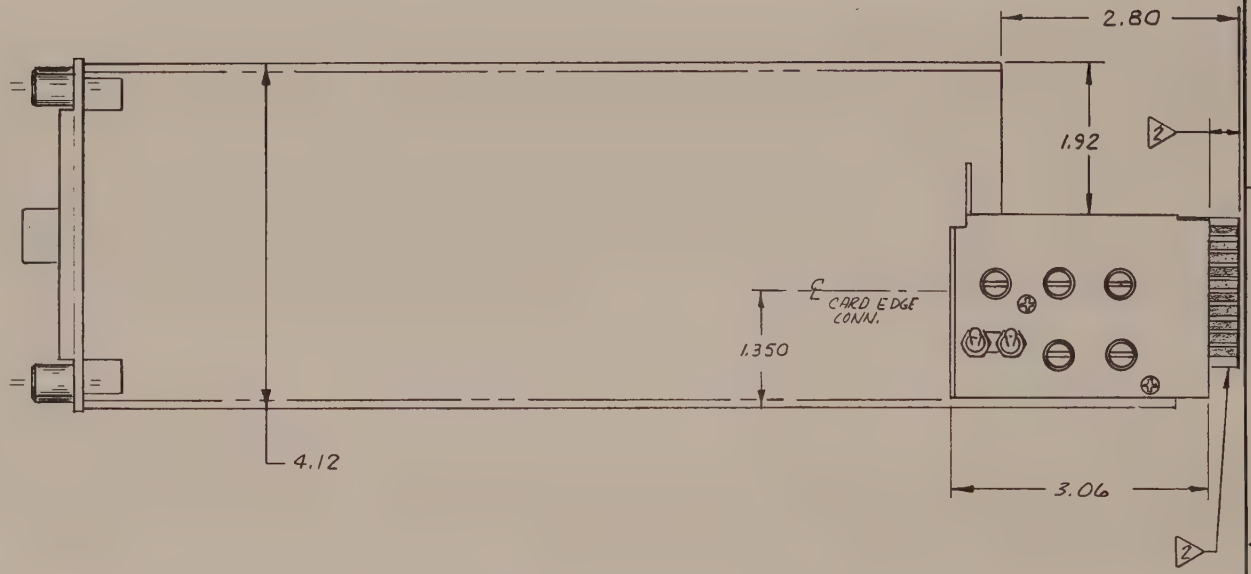
SCALE 1/2 SHEET 1 OF 2

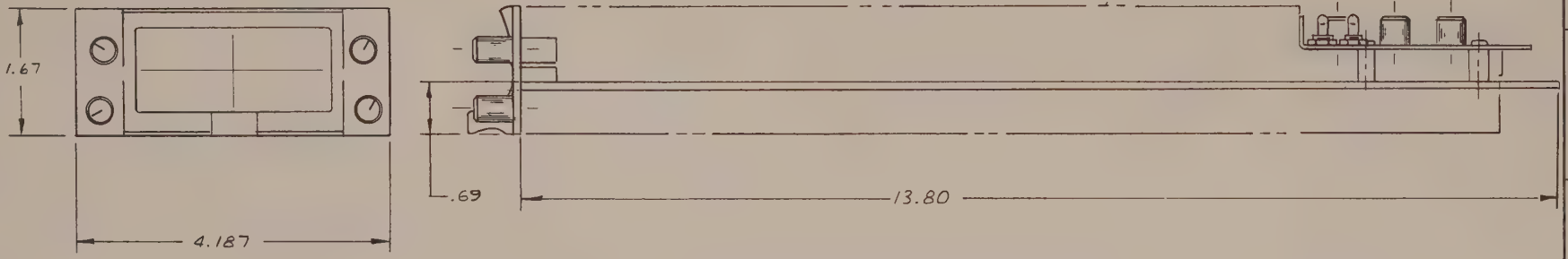
C7520-900 A

REVISIONS						
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD



RECOMMENDED MOUNTING CUTOUT FOR INDIVIDUAL MODULE MTG





ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE
REQD PER ASSY							

3 SLOT SHOULD BE A MINIMUM OF 8 INCHES LONG TO PROVIDE ADAQUATE SUPPORT FOR MODULE.

2 CARD EDGE CONNECTOR MATES WITH U.S. COMPONENTS, INC. P/N UPCR93-D10-DS. INSERTION DEPTH IS .296.

NOTES: (UNLESS OTHERWISE SPECIFIED)

DASH NO.	QTY REQD	NEXT ASSEMBLY	EFF ON	AUTH

DIM IN INCHES TOLERANCES .XXX = .010 .XX = .03 X° = 30'

BREAK ALL SHARP CORNERS & EDGES MACH SURFACES ✓

DWG SIZE C

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TITLE OUTLINE DWG, OSCILLOSCOPE MODULE

MODEL 7500

RELEASE		3/19/71	
CHECKER		3/15/71	PURCHASING
DESIGN			PROJ ENGR
DRFTSMN	MARTIN M	2-7-71	CHF ENGR

CALICO

CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA

CONTRACT NO.

CODE IDENT 16067

DWG NO. C7520-900 REV. A

SCALE FULL SHEET 2 OF 2

CALICO F-102

C7520-900 A

A 1-7 (1-8 BLANK)

SECTION II

INSTALLATION

2-1 GENERAL

2-2 This section of the manual provides instructions for unpacking, inspection for in- shipment damage, pre-operational tests and mechanical installation of the Model 7500 Monitor Oscilloscope System.

WARNING

HIGH VOLTAGE (2000 volts dc)

This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied. Avoid contact with all input power connections, the high voltage power supply, and high voltage sections of the oscilloscope modules. Verify that these circuits have been grounded after power turnoff before touching circuitry.

2-3 INITIAL INSPECTION IN CONTAINER

2-4 A visual inspection of the shipping container should be accomplished prior to acceptance from the carrier and if extensive damage to the shipping container is evident, a description of the damage should be noted on the carriers receipt and signed by the carriers agent.

2-5 UNPACKING

2-6 Each Model 7500 Monitor Oscilloscope System is shipped in a cardboard container with protective inner packing, according to best commercial standards, and can be unpacked using standard procedures. Do not destroy the packing containers unitl the unit has been inspected for possible damage in shipment.

2-7 INITIAL INSPECTION

2-8 Visually inspect the monitor oscilloscope system for obvious mechanical damage, dents, broken control switches, knobs, and glass. Remove the power supply cover and visually check for mechanical damage to the interconnect board and power supply. Remove each module from the unit and check for loose or broken components. If any damage is evident, notify the carrier. Do not return an instrument to the factory without prior approval.

2-9 POWER REQUIREMENTS

2-10 The CALICO Model 7500 Monitor Oscilloscope System operates from the 48 to 420 Hz power line. The unit is normally strapped for operation from 105 volts to 125 volts rms. Voltages above this limit may damage the oscilloscope and voltages below this limit will cause excessive noise and distortion to appear of the oscilloscope trace. The oscilloscope requires approximately 75 watts from the ac line.

2-11 FUSE PROTECTION

2-12 The Model 7500 Monitor Oscilloscope System is protected by a single 1.0 ampere 125 volt slow-blow fuse located on the innerconnect board between the oscilloscope modules and the power supply. A 0.5 ampere 250 volt slow-blow fuse is used when the unit is strapped for operation from the 230 volt ac line.

2-13 POWER INPUT WIRING

2-14 The monitor oscilloscope system is supplied with a conventional three-prong power input plug on the end of a six-foot cable and is used with 115 volt ac lines with a capacity of 1 ampere or greater. In the case of a 230 volt ac line, it may be necessary to cut off the plug and replace it with one compatable with the existing 230 volt ac line.

2-15 PRELIMINARY CHECKS AND ADJUSTMENTS

2-16 Each Model 7500 Monitor Oscilloscope System is checked and adjusted at the factory and should, normally, not require adjustment at the time of installation other than setting of the front panel controls. However, the following checks should be performed to verify functional operation. A description of the location and function of all front panel and rear porch controls is given in paragraph 3-3 through 3.6 of this publication.

a) Install all modules in the rack adapter/power supply. Always turn power off before removing or replacing modules in the rack.

b) Connect the line cord of the unit to a 115 volts, 48 to 420 Hz line in series with a .3 KW watt-meter. The watt-meter should indicate approximately 75 watts.

c) The regulated power supply is now providing all necessary power to the seven oscilloscope modules, except for correct grid bias on the CRTS. Switch the TRACE control on the front of the rack adapter/ power supply to the "on" position. This applies the correct operating grid bias to each of the CRT'S.

d) Position the front panel controls of each module as follows:
   a) Rotary mode switch to the AC-REC position.
   b) HORIZ sweep rate control to 0.1 KHz and VERN sweep control fully counter clockwise.
   c) VERT sensitivity to 1 volt rms per inch.

e) With the above controls in the positions indicated, position the INTEN and FOCUS controls of each module as desired for a clearly defined trace on each module.

f) Check that the TRACE ANGLE controls of each module are operational and position the TRACE ANGLE of each module so that the sweep is parallel with the horizontal graticule lines.

g) Check that the VERT position controls of each module are operational. They should have sufficient range to deflect the trace off the screen of the CRT in both the upper and lower directions. Set the VERT position control so that it is aligned with the horizontal graticule line in the center of the CRT screen.

h) Check that the HORIZ position controls of each module are operational. They should have sufficient range as to deflect either the starting edge or the trailing edge to almost the center of the CRT screen. Set the HORIZ position control so that the trace starts at the left edge of the graticule of each module and extends past the right hand edge of the graticule.

i) Insert a 1 KHz sine wave signal into the REC input of each oscilloscope module through the input connectors located at the rear of the rack adapter/power supply. Adjust the output of the signal generator to 1 volt rms. Select the internal trigger mode of each module with the INT/EXT TRIG switch located at the rear of each module.

j) Each oscilloscope module should display a 1 KHz sine wave whose peak-to-peak amplitude is four major divisions with a tolerance of ± one-half of a minor division. Each oscilloscope module should also display 10 cycles of the incoming 1 KHz signal within ten major horizontal divisions.

k) Steps i and j should be repeated with an input signal applied to the REP input and with the front panel mode switch in the AC-REP position.

l) Check that the positive and negative (+/-) TRIG slope polarity toggle switch on each module is operational. Select the positive trigger slope polarity on each module with the TRIG (+/-) toggle switch. The sweep should now trigger on the positive slope of the input signal.

m) If further testing of the monitor oscilloscope system is required at this time, refer to section V of this manual for the complete test and maintenance procedure.

2-17 MECHANICAL INSTALLATION

2-18 The Calico Model 7500 Monitor Oscilloscope System is designed for mounting in a standard 19 inch rack. Adequate mechanical clearance and/or cooling should be provided so as to limit the upper ambient temperature to 55°C. The monitor oscilloscope should be mounted to the rack by means of the two-inch Zero Mfg. Co. rack slides which are provided for this purpose. These slides are used to provide easy access to the controls located on the rear porch of the oscilloscope modules.

2-19 SIGNAL INPUT WIRING

2-20 The input signals are brought into the oscilloscope through BNC connectors located on the rear of the power supply rack adapter as shown in Drawing Number C7520-900-1. These connectors are isolated from the chassis so "grounds" may be carried through the oscilloscope modules and grounded at the source only. This eliminates any signal inaccuracies created by ground loops. This feature is available by removing the ground strap located between A2E1 and A2E2 on the inner-connect board.

2-21 There are three BNC connectors for each oscilloscope module, one for the record input, one for the reproduce input, and one for the external trigger input of each oscilloscope module. This gives each seven module racks the capability of monitoring fourteen channels of information. Each module has a front panel switch which connects the input circuits to the proper connector.

2-22 Coaxial cable is used from the BNC connectors to the oscilloscope module connector and then up to the vertical attenuator. The total input capacitance of the unit is approximately 100 picofarad for each vertical input.

SECTION III

OPERATION

3-1 GENERAL

3-2 This section of the manual provides instructions for use and operation of each control and indicator, initial adjustments and control settings, start up procedure, normal operation, abnormal operation, and shut down procedures.

3-3 FRONT PANEL OPERATING CONTROLS AND INDICATORS

3-4 The front panel operating controls and indicators are shown in figure 3-1 and described in table 3-1 below.

TABLE 3-1. Controls and Indicators.

CONTROL/ INDICATOR	POSITION	FUNCTION	LOCATION
POWER	PUSH FOR OFF	The ac input power is removed from monitor oscilloscope when the indicator lamp is "off".	Lower left hand side of rack adapter/ power supply
	PUSH FOR ON	The ac input power is applied to monitor oscilloscope when the indicator lamp is lite.	
TRACE	OFF	The CRT'S in all modules are biased so that the trace is removed from the face of all CRT'S.	Lower left hand side of rack adapter/power supply
REC/REP (vertical input coupling mode)	AC-REP	This position selects the ac component of the signal present on the rear panel REP input for viewing on the screen of the module.	Lower left hand side of each oscilloscope module
	GND	This position disconnects all data inputs from the vertical amplifier of the module and then grounds the vertical input to the module for a zero reference check.	
	DC-REC	This position selects the total signal (including dc component) present on the rear panel REC input for viewing on the screen of the module.	

Table 3-1. Controls and Indicators (cont).

CONTROL/ INDICATOR	POSITION	FUNCTION	LOCATION
	GND	This position disconnects all data inputs from the vertical amplifier of the module and then grounds the input to the vertical amplifier for a zero reference check.	
	AC-REC	This position selects the ac component of the signal present on the rear panel REC input for viewing on the screen of the module.	
VERT VRMS/IN (vertical input attenuator)	.05	Provides a vertical sensitivity of 0.05 volts rms per inch.	Upper left hand side of each oscilloscope module.
	.1	Provides a vertical sensitivity of 0.10 volts rms per inch.	
	.2	Provides a vertical sensitivity of 0.2 volts rms per inch.	
	.5	Provides a vertical sensitivity of 0.5 volts rms per inch.	
	1.	Provides a vertical sensitivity of 1.0 volts rms per inch.	
	2.	Provides a vertical sensitivity of 2.0 volts rms per inch.	
	5.	Provides a vertical sensitivity of 5.0 volts rms per inch.	
	10.	Provides vertical sensitivity of 10.0 volts rms per inch.	

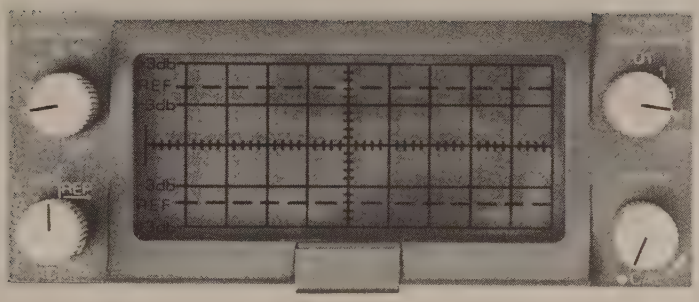


Figure 3-1. Front Panel Module Controls for Model 7510 Oscilloscope Module.

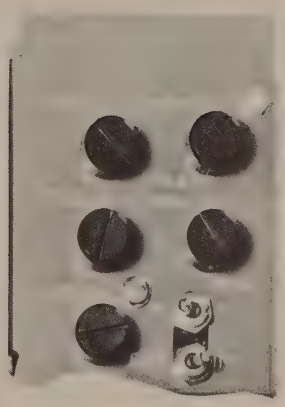


Figure 3-2. Rear Porch Controls for Model 7510 Oscilloscope Module.

Table 3-1. Controls and Indicators (cont).

CONTROL/ INDICATOR	POSITION	FUNCTION	LOCATION
HORIZ FREQ (KHz) (horizontal sweep frequency)	.01	Provides a horizontal sweep frequency of 10 Hz ie, sweeps at a rate of 10 milliseconds per major horizontal division.	Upper right hand side of each oscilloscope module.
	.1	Provides a horizontal sweep frequency of 100 Hz ie, sweeps at a rate of 1.0 milliseconds per major horizontal division.	
	1.	Provides a horizontal sweep frequency of 1000 Hz ie, sweeps at a rate of 100 microseconds per major horizontal division.	
	10.	Provides a horizontal sweep frequency of 10KHz ie, sweeps at a rate of 10 microseconds per major horizontal division.	
	100.	Provides a horizontal sweep frequency of 100 KHz ie, sweeps at a rate of 1.0 microsecond per major horizontal division.	
VERN (vernier sweep frequency control)	CAL	Provides calibrated operation for the HORIZ FREQ rotary switch listed above.	Lower right hand side of each oscilloscope module.
	VERN	Provides up to a 10 to 1 increase in sweep speed referenced to the setting of the HORIZ FREQ control in a smooth uncalibrated fashion.	

3-5 REAR PORCH CONTROLS

3-6 The rear porch controls are shown in figure 3-2 and described in table 3-2. These controls are normally accessible by pulling the rack adapter/ power supply away from the equipment rack with the CALICO supplied rack slides. These rear porch controls do not generally require a great deal of adjustment during operation of the monitor oscilloscope system.

TABLE 3-2. Rear porch controls.

CONTROL/ INDICATOR	POSITION	FUNCTION	LOCATION
VERT (vertical position control)	VARIABLE	This control is used to vertically position the trace on the CRT with respect to some predetermined point such as the graticule center line. This control has a sensitivity of approximately 25° rotation per major division of trace deflection.	Rear left hand side of the rear porch.
HORIZ (horizontal position control)	VARIABLE	This control is used to horizontally position the trace on the CRT with respect to some predetermined point such as starting the trace at the left hand edge of the graticule. This control has a sensitivity of approximately 22° rotation per major division of trace deflection.	Rear right hand side of the rear porch.
FOCUS	VARIABLE	This control is used to provide a sharp trace across the entire screen under all ambient lighting conditions. This control is usually used in conjunction with the INTEN control.	Center left hand side of the rear porch.
INTEN (intensity)	VARIABLE	This control is used to vary the trace brightness permitting the operator to adjust brightness to ambient light conditions, HORIZ FREQ and ease of viewing.	Front left hand side of the rear porch.

Table 3-2. Rear Porch Controls (cont).

CONTROL/ INDICATOR	POSITION	FUNCTION	LOCATION
TRACE ANGLE	VARIABLE	This control is used to align the trace with the horizontal graticule center line. This control provides approximately 20° of trace rotation over the full range of the control.	Center right hand side of the rear porch.
TRIG +/- (trigger slope polarity)	+	This position causes the horizontal sweep of the oscilloscope to start on the positive slope of either the vertical signal or the positive slope of the external trigger signal as determined by the setting of the EXT/ INT control.	Front right hand side of the rear porch.
	-	This position causes the horizontal sweep of the oscilloscope to start on the negative slope of either the vertical signal or the negative slope of the external trigger signal as determined by the setting of the EXT/INT control.	
EXT/INT (external/ internal trigger)	EXT	This position causes the oscilloscope to trigger on an external signal present on the rear panel EXT TRIG BNC connector.	Front right hand side of the rear porch.
	INT	This position causes the oscilloscope to trigger on the signal presented to the vertical amplifier.	

3-7 INITIAL ADJUSTMENTS AND CONTROL SETTINGS

3-8 The CALICO Model 7500 Monitor Oscilloscope System has been adjusted at the factory and should require no special adjustments prior to operation. Section 2-15 of this instruction manual discusses pre-operational checks and adjustment of all front panel and rear porch controls.

3-9 START UP PROCEDURE

3-10 The CALICO Model 7500 Monitor Oscilloscope System is started according to the following procedure:

a) Push the red POWER indicator located at the left side of the front panel of the rack adapter/power supply. Observe that this indicator is lighted.

b) Allow two minutes for the CRT filiments to warm up to operating temperature.

c) Set the TRACE switch to the "on" position and observe the trace on the face of the CRTS.

3-11 NORMAL OPERATION

3-12 Adjust the oscilloscope module operating controls to the desired positions to observe the desired waveform on the face of the CRTS.

3-13 ABNORMAL OPERATION

3-14 Push the POWER indicator to remove power from the unit and check that the proper signals and ac input power are availiable to the monitor oscillocope. If problems are still encountered, refer to the maintenance section of this publication.

3-15 SHUT DOWN PROCEDURE

3-16 The shut down procedure consists of pushing the POWER indicator and observing that the indicator goes out and that the trace disappears from the face of all CRT'S.

SECTION IV

PRINCIPLES OF OPERATION

4-1 INTRODUCTION

4-2 This section of the instruction manual describes the theory of operation for the CALICO Model 7500 Monitor Oscilloscope System from both a functional view point and a detailed circuit view point.

4-3 FUNCTIONAL DESCRIPTION

4-4 The basic purpose of this seven channel monitor oscilloscope is to observe, monitor and measure the amplitude, frequency and waveform of up to seven signals in a simultaneous fashion while requiring a minimum amount of vertical rack height. In order to accomplish this function with a minimum of adjustments, it is necessary that the oscilloscope display remain calibrated and stable with variations in vertical sensitivity, horizontal sweep rate, trigger signal amplitude and frequency, ambient temperture, and input line voltage. Physically, it is necessary that the modules be designed to optimize the ratio of CRT viewing area to the total front panel area.

4-5 A block diagram for the oscilloscope module is given in figure 4-1 and a block diagram for the rack adapter/power supply is given in figure 4-2.

4-6 FUNCTIONAL DESCRIPTION OF A SINGLE OSCILLOSCOPE MODULE

4-7 Figure 4-1 illustrates the functional block diagram for a single oscilloscope module. The module may be considered to be divided into three seperate major sections. These are:

a) The vertical signal conditioning section where the signal is coupled, attenuated, amplified and conditioned for application to the vertical deflection plates of the CRT.

b) The horizontal signal generation and conditioning section where a linear sweep is initiated, amplified and conditioned for application to the horizontal deflection plates of the CRT upon receipt of a trigger signal.

c) The display section where the CRT is biased for proper operation.

4-8 FUNCTIONAL DESCRIPTION OF VERTICAL CONDITIONING SECTION

4-9 The function of the vertical conditioning section of the module is to couple, attenuate, amplify and position the desired vertical input signal on the screen of the oscilloscope such that the beam of the CRT is deflected in a linear fashion in the upward direction for positive input voltages and in the downward direction for negative input voltages.

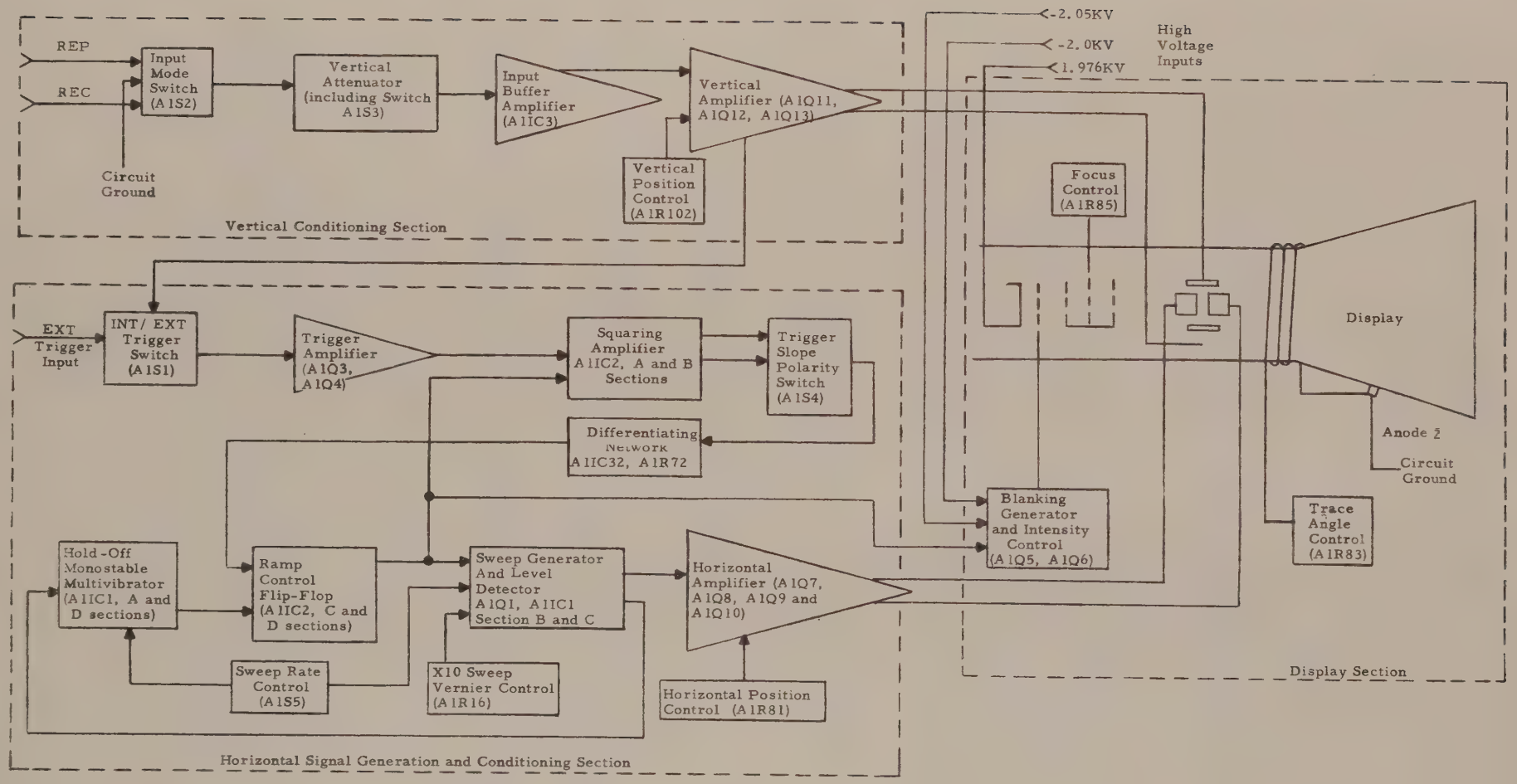

REP
REC
Input Mode Switch (A1S2)
Circuit Ground
Vertical Attenuator (including Switch A1S3)
Input Buffer Amplifier (A1IC3)
Vertical Amplifier (A1Q11, A1Q12, A1Q13)
Vertical Position Control (A1R102)
Vertical Conditioning Section
-2.05KV
-2.0KV
1.976KV
High Voltage Inputs
Focus Control (A1R85)
Display
Anode 2
Circuit Ground
EXT Trigger Input
INT/ EXT Trigger Switch (A1S1)
Trigger Amplifier (A1Q3, A1Q4)
Squaring Amplifier A1IC2, A and B Sections
Trigger Slope Polarity Switch (A1S4)
Differentiating Network A1IC32, A1R72
Blanking Generator and Intensity Control (A1Q5, A1Q6)
Trace Angle Control (A1R83)
Hold-Off Monostable Multivibrator (A1IC1, A and D sections)
Ramp Control Flip-Flop (A1IC2, C and D sections)
Sweep Generator And Level Detector A1Q1, A1IC1 Section B and C
Horizontal Amplifier (A1Q7, A1Q8, A1Q9 and A1Q10)
Sweep Rate Control (A1S5)
X10 Sweep Vernier Control (A1R16)
Horizontal Position Control (A1R81)
Horizontal Signal Generation and Conditioning Section
Display Section

Figure 4-1. Monitor Oscilloscope, Functional Block Diagram for a Single Module

4-10 INPUT MODE SWITCH

4-11 The function of the input mode switch, consisting of switch A1S2 and associated components, is to select one of five operating modes of operation from the front panel of the module. These are the ac reproduce mode (AC-REP), the dc reproduce mode (DC-REP), the dc record mode (DC-REC), the ac record mode (AC-REC), and a signal ground mode (GND).

4-12 VERTICAL ATTENUATOR

4-13 The function of the vertical attenuator, consisting of rotary switch A1S3 and associated components, is to select one of eight sensitivities from 50 millivolts rms per inch to 10 volts rms per inch. In the 0.05 volt position, the vertical attenuator is by-passed and the vertical signal is applied directly to the input buffer amplifier. In the 0.1 volt position, the vertical attenuator provides an attenuation of 2 to 1 by means of a conventional RC attenuator network. The resistive part of the divider attenuates the low frequency components of the input signal and the capacitive part of the divider attenuates the high frequency components of the input signal. Table 4-1 lists the attenuation ratio provided by the attenuator.

TABLE 4-1. Vertical Attenuator Positions.

SENSITIVITY POSITION	ATTENUATION
0.05 volts per inch	1.0 to 1.0
0.10 volts per inch	2.0 to 1.0
0.20 volts per inch	4.0 to 1.0
0.50 volts per inch	10.0 to 1.0
1.0 volts per inch	20.0 to 1.0
2.0 volts per inch	40.0 to 1.0
5.0 volts per inch	100.0 to 1.0
10.0 volts per inch	200 to 1.0

4-14 INPUT BUFFER AMPLIFIER

4-15 The function of the buffer amplifier, consisting of integrated circuit A1IC3 and associated components, is to prevent the relatively low input impedance of the vertical amplifier from effecting the electrical performance of the vertical attenuator in an adverse fashion.

4-16 VERTICAL AMPLIFIER

4-17 The function of the vertical amplifier, consisting of transistors A1Q11, A1Q12, A1Q13, and associated components is to provide the gain required to amplify the attenuated input signal to such a level so as to deflect the CRT display 1.0 inch peak-to-peak for a full scale input signal on any vertical attenuator range.

4-18 VERTICAL POSITION CONTROL

4-19 The function of the vertical (VERT) position control , A1R102, is to adjust the vertical position of the oscilloscope display, independent of the setting of the vertical attenuator so that the trace is aligned with the center of the graticule under zero signal conditions. The electrical location of this control is also such that its' operation does not effect the gain of the vertical amplifier.

4-20 FUNCTIONAL DESCRIPTION OF HORIZONTAL SIGNAL GENERATION AND CONDITIONING SECTION

4-21 The function of this section of the module is to provide a linear time base, moving from left to right, across the screen of the oscilloscope in synchronism with an externally generated trigger signal, if such a trigger signal is present. If this trigger signal is not present, this section of the oscilloscope provides a free-running linear time base at a moderately low repetition rate.

4-22 INT/EXT TRIGGER SWITCH

4-23 The function of the internal/external trigger (INT/EXT TRIG) switch, A1S1, is to select either an external trigger signal or a sample of the vertical signal for synchronizing the horizontal time base.

4-24 TRIGGER AMPLIFIER

4-25 The function of the trigger amplifier, consisting of A1Q3, A1Q4 and associated components, is to allow the oscilloscope to trigger from extremely small trigger signals over a frequency range from 10 Hz to 10 MHz without loading the source of trigger signals excessively. If no trigger signal is present, this circuit will go into a free-running mode. In this mode of operation, the trigger amplifier will provide a 25 to 50 Hz non-synchronous output for generation of a reference trace across the face of the CRT.

4-26 SQUARING AMPLIFIER

4-27 The function of the squaring amplifier, consisting of sections A and B of A1IC2 and associated components, is to generate a pair of square waves 180 degrees out of phase with each other at the same frequency and the same phase timing of the incoming trigger signal. These square wave signals have extremely fast rise and fall times in order to minimize timing errors at high sweep rates.

4-28 TRIGGER SLOPE POLARITY SWITCH

4-29 The function of the trigger slope polarity (+/-TRIG) switch, A1S4, is to select the proper output of the squaring amplifier for application to the differentiating network.

4-30 DIFFERENTIATING NETWORK

4-31 The function of the differentiating network, Capacitor A1C32 and resistor A1R72, is to obtain a sharp positive going pulse to trigger the ramp control flip-flop into the "1" state.

4-32 RAMP CONTROL FLIP-FLOP

4-33 The function of the ramp control flip-flop, consisting of sections C and D of integrated circuit A1IC2 and associated components, is to provide a "1" output (+3.5 volts) during the linear time base and a "0" output (0 volts) during the retrace and hold-off time period.

4-34 SWEEP GENERATOR AND LEVEL DETECTOR

4-35 The function of the sweep generator and level detector, consisting of transistor array A1Q1 sections A through E, transistor A1Q2 and integrated circuit A1IC1, sections B and C, and associated components, is to generate a linear ramp from 0 volts to +11 volts at a ramp rate controlled by the sweep rate control. This circuit also provides a "1" output (+3.5 volts) when the linear ramp reaches +11 volts for activating the hold-off monostable multivibrator.

4-36 SWEEP RATE CONTROL

4-37 The function of the sweep rate control, consisting of switch A1S5 and capacitors A1C37 through A1C41 and capacitors A1C45 through A1C50, is to control the rate of the sweep generator output in decade steps from the front panel of the oscilloscope module. In order to perform this function in an optimum fashion, it is also necessary that the hold-off monostable multivibrator timing be switched simultaneously with the sweep rate.

4-38 X10 SWEEP VERNIER CONTROL

4-39 The function of the X10 sweep vernier (VERN) control, consisting of potentiometer A1R16 , is to control the rate of the sweep generator output in a smooth fashion between decade steps of the sweep rate control from the front panel of the oscilloscope module.

4-40 HOLD-OFF MONOSTABLE MULTIVIBRATOR

4-41 The function of the hold-off monostable multivibrator, consisting of integrated circuit A1IC1 section A and D and associated components, is to inhibit the generation of a second linear ramp until the previous ramp and associated circuit transients have gone to zero volts.

4-42 HORIZONTAL AMPLIFIER

4-43 The function of the horizontal amplifier, consisting of transistor A1Q7, A1Q8, A1Q9, A1Q10 and associated components, is to amplify the sweep generator output in a linear fashion and to such a level as to deflect the CRT display greater than 2.5 inches peak-to-peak in the horizontal direction.

4-44 HORIZONTAL POSITION CONTROL

4-45 The function of the horizontal position (HORIZ) control, consisting of potentiometer A1R81, is to adjust the horizontal position of the oscilloscope display, independent of the gain of the horizontal amplifier, so that the left hand edge of the trace is aligned with the left hand edge of the graticule.

4-46 FUNCTIONAL DESCRIPTION OF DISPLAY SECTION

4-47 The function of this section of the module is to provide proper operating voltages for the CRT in order to present a clear, sharp display of the incoming information.

4-48 BLANKING GENERATOR

4-49 The function of the blanking generator, consisting of transistors A1Q5, A1Q6 and associated components, is to cut-off the display during the retrace and hold-off time period so that these operations will not be displayed on the face of the CRT.

4-50 FOCUS CONTROL

4-51 The function of the focus (FOCUS) control, consisting of potentiometer A1R85 and associated components, is to provide that dc voltage required at the focus electrode which results in the sharpest display of the face of the CRT.

4-52 TRACE ANGLE CONTROL

4-53 The function of the trace angle (TRACE ANGLE) control, consisting of potentiometer A1R83 and associated components, is to provide a control which rotates the display about the center of the face of the CRT. This allows the operator to manually adjust the display so that the horizontal sweep is aligned with the horizontal graticule lines and that the vertical input is aligned with the vertical graticule lines.

4-54 FUNCTIONAL DESCRIPTION OF THE RACK ADAPTER/POWER SUPPLY

4-55 Figure 4-2 illustrates the functional block diagram for the rack adapter/power supply. The rack adapter/power supply may be considered to be

divided into five seperate major sections. These are:

a) The power transformer which provides the raw ac power for application to the various voltage regulators and to the filiments of the CRTS.

b) The high voltage power supply which provides the required dc voltages for application to the display circuit of each oscilloscope module.

c) The low voltage power supply which provides the required dc voltages for application to the vertical amplifier, horizontal amplifier and sweep generator portions of each oscilloscope module.

d) The module connectors and mechanical innerface which provides all electrical power input and signal input to the oscilloscope module as well as supplying mechanical support and guiding for the oscilloscope modules.

e) The rear panel input connectors which provide all electrical signal input to the rack adapter power supply.

4-56 DETAILED CIRCUIT DESCRIPTION OF VERTICAL SECTION OF THE MODULE

4-57 A schematic diagram for the oscilloscope module is given in drawing E7510-070. Each module is designated as the A1 assembly. The vertical section of the module is divided into four sections. These are:

a) The Input Mode Switching,

b) The Vertical Attenuator,

c) The Input Buffer Amplifier,

d) The Vertical Amplifier.

These sections of the module are described in the following sections of this publication.

4-58 INPUT MODE SWITCHING

4-59 The input mode switch, A1S2, is a six-position single-pole rotary switch which is used to select one of five inputs. These are the ac reproduce mode (AC-REP), the dc reproduce mode (DC-REP), the dc record mode (DC-REC), the ac record mode (AC-REC), and a signal ground mode. In the dc mode of operation, the desired input signal is coupled directly from either the REC or REP input into the vertical attenuator. In the ac mode of operation, the desired input signal is coupled through an isolation capacitor (either A1C9 or A1C10) into the vertical attenuator. In the signal ground mode, neither input signal is used, and the input to the vertical attenuator is directly connected to circuit ground.

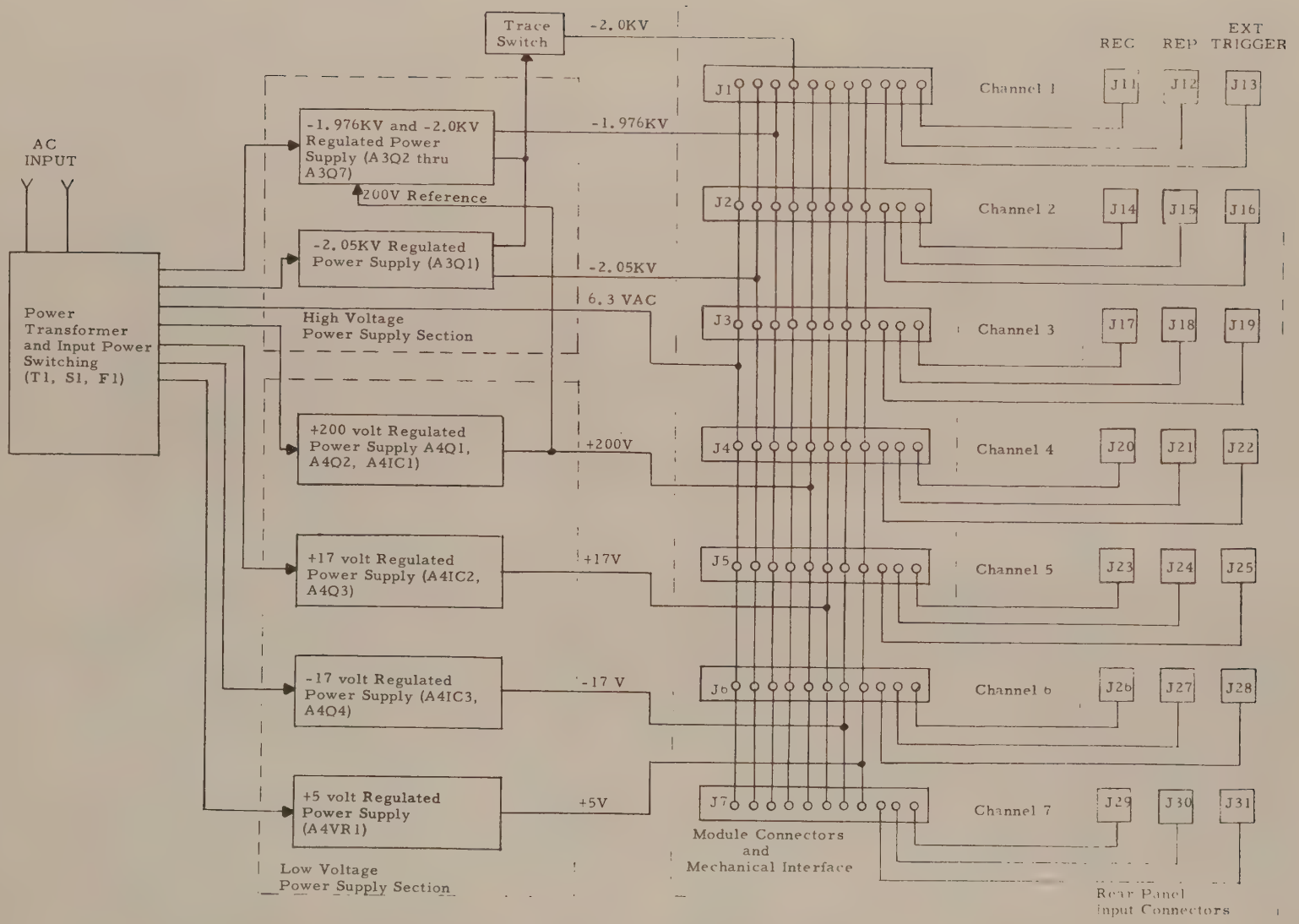


Figure 4-2. Monitor Oscilloscope, Functional Block Diagram For Rack Adapter/Power Supply.

4-60 VERTICAL ATTENUATOR

4-61 The vertical attenuator consists of an eight-position four pole rotary switch, A1S3, and the associated resistance-capacitance divider networks. The vertical attenuator is used to scale the input signal so as not to overdrive (or under drive) the fixed gain vertical amplifier. The vertical attenuator provides attenuation factors of 1, 2, 4, 10, 20, 40, 100 and 200 to one as determined by the front panel VERT sensitivity control. The attenuator provides accurate voltage division at dc and low frequencies by the use of a precision resistive divider. At high frequencies, voltage division is achieved by a capacitive divider. The cross over frequency is approximately 40 KHz. When properly compensated, the attenuator has a flat frequency response from dc to 10 MHz on all ranges. The input impedance of the attenuator is a fixed 1 megohm on all attenuation ranges.

4-62 INPUT BUFFER AMPLIFIER

4-63 The input buffer amplifier, integrated circuit A1IC3 and associated components, is a voltage follower which provides a fixed gain of 1.0 while isolating the vertical attenuator from the low input impedance vertical amplifier. This integrated circuit uses super beta input transistors which holds the input current to less than 10 nanoamperes over the temperature range of 0 to 70°C and holds the input voltage drift to less than 10 microvolts per degree centigrade. As a result, it is not necessary to use any vertical drift compensation controls with this monitor oscilloscope system. The input buffer amplifier is protected against over-voltage inputs by means of diodes A1CR8, A1CR9 which limit the maximum input voltage into the buffer amplifier.

4-64 VERTICAL AMPLIFIER

4-65 The vertical amplifier consists of transistor array A1Q11, transistor A1Q12, A1Q13 and associated components connected in a differential configuration. This amplifier produces a one inch peak-to-peak vertical deflection of the CRT display for a 0.05 volt rms sine wave input and has a gain of approximately 160 from dc to 10 MHz.

4-66 The transistor array A1Q11 consists of five monolithic npn transistors internally connected to form three isolated transistors and one differential pair. These devices exhibit excellent thermal tracking characteristics due to their monolithic integrated circuit construction and are ideal for use in wide band video amplifiers. Transistors A1Q11A and A1Q11B are connected in a differential amplifier configuration with operational feedback from each collector to the corresponding base. Transistor A1Q11E is connected as a constant current source to provide emitter current for A1Q11A and A1Q11B. This input stage provides a gain of approximately -20 over the frequency range from dc to 10MHz from pin 6 of A1IC3 to the collector of A1Q11A and a gain of approximately +20 from pin 6 of A1IC3 to the collector of A1Q11B. Potentiometer A1R102, resistor A1R98 and A1R101 determines the dc input into the other input of this differential amplifier and is used to set the vertical position of the display of the face of the CRT. Figure 5-6 a illustrates the waveform of the signal at the collector of A1Q11B with a 250Hz full scale sine wave signal applied to the input of the vertical amplifier.

4-67 Transistors A1Q11C and A1Q11D are connected in a differential emitter follower configuration and are used to isolate the collectors of A1Q11A and A1Q11B from the input capacitance associated with A1Q12 and A1Q13. This stage provides a voltage gain of approximately 1.0 from dc to 10MHz. Resistor A1R110 is used to couple a portion of the signal availiable at the emitter of A1Q11C to the INT/EXT TRIG switch.

4-68 Transistors A1Q12 and A1Q13 are connected in a differential amplifier configuration with emitter degeneration and provide a voltage gain of approximately 8 from dc to 10MHz. Potentiometer A1R104, in the emitter circuit of A1Q12 and A1Q13, is used to adjust this gain somewhat so that a 50 millivolt rms sine wave input will produce a one-inch peak-to-peak vertical deflection on the face of the CRT. Capacitor A1C54 inductors A1L4, A1L5 provide additional high-frequency gain to compensate for the collector capacitance of A1Q12, A1Q13, and the vertical deflection plate capacitance of the CRT, A1V1. Figure 5-6 shows an oscillogram of the waveform at the collector of A1Q13 with full scale sine wave signal applied to the input of the vertical amplifier.

4-69 Resistors A1R2, A1R3 and capacitors A1C4, A1C5 are used to decouple the +17 volt and -17 volt power lines in the vertical amplifier of the module from the +17 volt and -17 volt power lines in other modules as well as seperating the vertical amplifier ±17 volt power lines from other sections of the module.

4-70 DETAILED CIRCUIT DESCRIPTION OF HORIZONTAL SIGNAL GENERATION AND CONDITIONING SECTION OF THE MODULE

4-71 A schematic diagram for the oscilloscope module is given in drawing E7510-070. Each module is designated as the A1 assembly. The horizontal section of the module is divided into ten sections. These are:

a) The Internal/External Trigger Selection Control.

b) The Trigger Source Follower.

c) The Trigger Amplifier.

d) The Squaring Amplifier and Trigger Slope Polarity Switch.

e) The Differentiating Network.

f) The Ramp Control Flip-Flop.

g) The Sweep Generator and Level Detector.

h) The Sweep Rate Controls.

i) The Hold-Off Generator.

j) The Horizontal Amplifier.

These sections of the module are described in detail in the following paragraphs of this publication.

4-72 THE INTERNAL/EXTERNAL TRIGGER SELECTION CONTROL

4-73 The INT/EXT TRIG control consists of toggle switch A1S1. This single-pole double-throw toggle switch is used to select either a sample of the vertical signal or an external signal for application to the trigger amplifier.

4-74 THE TRIGGER SOURCE FOLLOWER

4-75 The trigger source follower consists of field effect transistor A1Q3 and associated components. This circuit provides a high input impedance and a gain of approximately 1.0 from 10 Hz to 10 MHz. Diodes A1CR2, A1CR5 and resistor A1R13 are used to protect the field effect transistor from excessive amplitude input signals.

4-76 THE TRIGGER AMPLIFIER

4-77 The trigger amplifier consists of transistor array A1Q4 and associated components connected so as to form a high gain ac coupled amplifier. This amplifier provides an open loop gain of approximately 200 from 20Hz to greater than 1 Mhz and attenuating to approximately 50 at 10 MHz. Figure 5-6 c shows an oscillogram of the signal at the output of the trigger amplifier with a 250Hz sine wave signal applied to the input of the vertical amplifier and with the INT/EXT TRIG switch in the internal position.

4-78 Transistors A1Q4A and A1Q4B are connected so as to form a differential amplifier with a mid-band open loop voltage gain of approximately 100. Transistor A1Q4C is connected in the grounded emitter configuration and supplies a mid-band open loop voltage gain of approximately 2.0. Transistor A1Q4D is connect in the emitter follower configuration and provides a voltage gain of approximately 1.0. Transistor A1Q4E is used as a 10 milliampere constant current sink to the -17 volt dc power supply.

4-79 The trigger amplifier encorporates two overall feedback loops These are:

a) A negative feedback loop consisting of resistor A1R36 and capacitor A1C20 which reduces the closed loop voltage gain of the trigger amplifier to 1.0 at dc. The purpose of this negative feedback loop is to stablize the dc operating points of all stages of the trigger amplifier.

b) A positive feedback loop consisting of resistors A1R18, A1R20 A1R50 and capacitor A1C14. The purpose of this positive feedback loop is to provide regeneration of trigger signals exceeding 0.1 volt peak-to-peak amplitude at the gate of A1Q3. If the trigger signal is less than 0.1 volt peak-to-peak at the gate of A1Q3 then this positive feedback loop converts the operation of the trigger amplifier into that of a free-running multivibrator whose output frequency is determined by the value of A1C14, A1C20, A1R36, A1R50, and the open loop gain of the trigger amplifier. In this mode of operation the trigger amplifier generates a square wave output whose output frequency is approximately 25 to 50 Hz and whose amplitude is limited to approximately +4 volts and -3 volts referenced to circuit ground potential.

4-80 For trigger signals greater than 0.1 volt peak-to-peak at the gate of A1Q3 the output of the trigger amplifier, at pin 14 of A1Q4E, is a square wave whose frequency is equal to that of the input signal at the gate of A1Q3 and whose zero crossings are in phase with those of the input signal. The amplitude of the square wave at the pin 14 of A1Q4E is limited to +4 volts and -3 volts referenced to circuit ground potential.

4-81 THE SQUARING AMPLIFIER AND TRIGGER SLOPE POLARITY SWITCH

4-82 The squaring amplifier consists of integrated circuit A1IC2A, A1IC2B and associated components connected so as to form an RS flip-flop. Resistors A1R51 and A1R57 form the required positive feedback loop around the flip-flop.

4-83 During the linear sweep period, pin 6 of A1IC2B is driven to the "1" state (+3.5 volts) by the output of A1IC2D, pin 13. This causes the squaring amplifier to "lock up" with a +3.5 volt output at A1IC2A pin 1 as shown in the oscillogram illustrated in figure 5-6d.

4-84 During the retrace and hold-off period, pin 6 of A1IC2B is driven to the "0" state (0 volts) by the output of A1IC2D, pin 13. This causes the squaring amplifier to respond to the output of the trigger amplifier via resistor A1R51. The squaring amplifier output at either A1IC2 pin 1 or pin 4 exhibits a rise time of approximately 10 nanoseconds. The two outputs of the squaring amplifier are used to drive the trigger slope polarity switch, A1S4. Assuming that a trigger pulse of the proper polarity is present at A1Q4 pin 14 and that the sweep generator is ready to be triggered, the operation of the squaring amplifier is as follows:

a) With switch A1S4 in the positive slope position, A1IC2A pin 1 will be switched into the "1" state and will remain in the "1" state until the completation of the linear sweep period due to the "1" state input at A1IC2B pin 6. After the completation of the linear sweep period, the input at pin 6 of A1IC2B will return to the "0" state. Therefore, the output of A1IC2A pin 1 will track the output of the trigger amplifier until the ramp control flip-flop is ready to accept another trigger input signal at pin 8 of A1IC2C.

b) With switch A1S4 in the negative slope position, A1IC2B pin 4 will go to the "1" state upon receipt of a trigger signal but will immediately return to the "0" state due to the "1" state input at pin 6 of A1IC2B. This total switching time will be less than 25 nanoseconds. After the completion of the linear sweep period, the input at pin 6 of A1IC2B will return to the "0" state. Therefore, the output of A1IC2B pin 4 will follow the output of the trigger amplifier in an inverted fashion until the ramp control flip-flop is ready to accept another trigger input signal at pin 8 of A1IC2C.

4-86 THE DIFFERENTIATION NETWORK

4-87 The differentiating network consists of capacitor A1C32 and resistor A1R72 and has a time constant of approximately 25 nanoseconds. Therefore, the differentiating network only transmits changes in the logic state of the squaring amplifier, to the ramp control flip-flop, A1IC2C and A1IC2D.

4-88 THE RAMP CONTROL FLOP-FLOP

4-89 Figure 5-6 e shows an oscillogram of the waveform at the output of the ramp control flip-flop, pin 13 of A1IC2D. The ramp control flip-flop consists of integrated circuit A1IC2C, A1IC2D connected so as to form an RS flip-flop. During the linear sweep time pin 13 of A1IC2D is driven into the "1" state by a positive trigger pulse at pin 8 of A1IC2C which starts a linear sweep at A1Q1C pin 7 in synchronism with the trigger pulse. Additional trigger pulses are inhibited from appearing at A1IC2C pin 8 until the linear sweep is completed by means of digital feedback to pin 6 of A1IC2B. At the completion of the linear sweep and during the retrace and hold-off period, pin 12 of A1IC2D is driven to the "1" state by the output of A1IC1A pin 1. This causes pin 13 of A1IC2D to be locked into the "0" state until the removal of the "1" at pin 12 of A1IC2D. Pin 13 of A1IC2D will not respond to trigger pulses at A1IC2C pin 8 during this time interval. After the retrace and hold-off time period is completed, pin 1 of A1IC1A returns to the "0" state and the next positive pulse at pin 8 of A1IC2C will cause pin 13 of A1IC2D to be driven to the "1" state, which starts another linear sweep.

4-90 THE SWEEP GENERATOR AND LEVEL DETECTOR

4-91 The sweep generator and level detector consists of transistor array A1Q1 sections A through E, A1Q2, integrated circuit A1IC1B, A1IC1C and associated components connected so as to form a constant current source type ramp generator, a gain of 1.0 isolation amplifier, and a level detector to sense the desired upper limit output voltage from the ramp generator. Figure 5-6 f illustrates the output of the sweep generator on the 0.1KHz HORIZ sweep range and with a 250Hz vertical input signal.

4-92 The linear ramp is generated by charging one of several capacitors, A1C46 through A1C50, from a constant current source formed from A1Q2, A1R9, A1R12, A1R15, A1R16 and associated components. The collector of transistor A1Q2 supplies a dc current of approximately 100 microamperes with potentiometer A1R16 in the fully counter clockwise position (VERN control in CAL position) and approximately 1.0 milliampere dc with potentiometer A1R16 in the fully clockwise position (X 10 sweep rate). Diode A1CR1 is used to compensate for the temperature coeficient of the emitter-base junction of A1Q2, thereby maintaining a constant collector current from A1Q2 as the ambient temperature is varied. The dc current availiable from the collector of A1Q2 is used to charge the integrating capacitor, A1C46 through A1C50, from zero volt to approximately +11 volts in a linear fashion. The time required to charge the integrating capacitor from zero volts to +11 volts is equal to the time required to sweep the trace from the left side of the cathode ray tube to the right side of the cathode ray tube. At the end of the linear sweep, transistor A1Q1A is switched "on" from the "1" state output at pin 4 of A1IC1B obtained when pin 13 of the ramp control flip-flop returns to the "0" state at the end of the linear sweep. This causes the integrating capacitor to rapidly discharge with a time constant dependent of the size of the integrating capacitor and the series resistance of transistor A1Q1A in the "on" state. When pin 7 of A1Q1C reaches zero volts, A1CR4 conducts and thereby reduces the base drive to A1Q1A. This biases A1Q1A into the linear operating region and thereby holds the emitter of A1Q1C at zero volts until the start of the next linear sweep period.

4-93 Transistors A1Q1C, A1Q1D and A1Q1E are connected so as to form a dc amplifier whose voltage gain is approximately 1.0 and whose input impedance, at pin 9 of A1Q1D is extremely high. The high input impedance of this dc amplifier is used to isolate the ramp generator from the loading effects of the level detector and the horizontal deflection amplifier. Transistor A1Q1D is used in the emitter follower configuration with a dc collector current of approximately 230 microamperes. Transistor A1Q1E is connected as a constant current source and is used to supply the emitter current to A1Q1D. Transistor A1Q1C is used in the emitter follower configuration and is used to drive the level detector and the horizontal amplifier.

4-94 Transistors A1Q1A, A1Q1B, integrated circuit A1IC1C, diode A1CR6 and associated components are connected so as to form the level detector. When the ramp generator output, at pin 7 of A1Q1C reaches +11 volts, zener diode A1CR6 begins to conduct which causes the collector of transistor A1Q1B to conduct and bias A1IC1C pin 8 to the "0" state for an instant as illustrated in figure 5-6 g. This in turn drives A1IC1C pin 10 to the "1" state (+3.5 volts), for an instant. This activates the hold-off monostable multivibrator, which in turn, causes pin 13 of the ramp control flip-flop to return to the "0" state.

4-95 THE SWEEP RATE CONTROLS

4-96 The sweep rate controls consist of potentiometer A1R16 (VERN), switch A1S5 (HORIZ FREQ) and capacitors A1C37 through A1C41 and capacitors A1C45 through A1C50. Capacitors A1C45 through A1C50 are switched by A1S5 from the front panel to control the time base output in decade steps. The capacitors are ratio matched to exactly 10 to 1 ±1 per cent of each other so that the sweep calibration does not change significantly as the sweep range is changed. Table 4-2 below shows the nominal time of the linear sweep for each range with the VERN control in both the fully clock wise and counter clockwise positions.

Table 4-2. Linear Sweep Time.

FREQUENCY RANGE	SWEEP TIME with A1R16 CCW (calibrated sweep)	SWEEP TIME with A1R16 CW (X10 sweep)
.01KHz	105 milliseconds	10.0 milliseconds
.1KHz	10.5 milliseconds	1.0 millisecond
1KHz	1.05 millisecond	100 microseconds
10KHz	105 micro seconds	10 microseconds
100 KHz	10.5 microseconds	1.0 microsecond

The sweep time is approximately 5 per cent greater than the time required to sweep across 10 major divisions of the CRT face since the oscilloscope is normally set to sweep approximately 5 per cent beyond the right end of the graticule. Potentiometer A1R16 is used to vary the integrating current from 100 microamperes dc to 1 milliampere dc from the front panel. This allows the time base to be adjusted to any desired value between the decade steps.

4-97 Capacitors A1C37 through A1C41 are used to control the minimum time between sweeps and is also controlled by switch A1S5. This allows the sweep generator adequate time to recover before another linear sweep may be initiated. Table 4-3 below shows the nominal hold-off time for each range. This hold-off time is independent of the setting of the VERN sweep control.

Table 4-3. Hold-off Time.

FREQUENCY RANGE	HOLD-OFF TIME
.01KHz	3.5 milliseconds
.1KHz	350 microseconds
1KHz	35 microseconds
10KHz	15 microseconds
100KHz	4 microseconds

4-98 THE HOLD-OFF GENERATOR

4-99 The hold-off generator consists of integrated circuit A1IC1A and A1IC1D connected so as to form a monostable multivibrator. At the end of each linear ramp pin 10 of A1IC1C is monentarialy driven to the "1" state by the conduction through zener diode A1CR6 as was explained in paragraph 4-94 of this publication. This pulse, in turn, drives pin 1 of A1IC1A to the "1" state and allows the applicable hold-off capacitor, one of A1C37 through A1C41, to drive pin 12 of A1IC1D to the "1" state. This, in turn, holds pin 13 of A1IC1D in the "0" state until the hold-off capacitor no longer can supply sufficient current to maintain pin 12 of A1IC1D in the "1" state. At this time, pin 1 of A1IC1A returns to the "0" state, allowing the ramp control flip-flop A1IC2C and A1IC2D to respond to the next positive going pulse at pin 8 of A1IC2C. Figure 5-6 h illustrates the output of the hold-off generator on the 0.1KHz HORIZ sweep range.

4-100 THE HORIZONTAL AMPLIFIER

4-101 The horizontal amplifier consists of transistor A1Q7, A1Q8, A1Q9, A1Q10 and associated components connected so as to form a dc amplifier with a differential output for driving the horizontal deflection plates of the CRT. This amplifier provides a voltage gain of approximately 22 from the single ended input at pin 7 of A1Q1C to the differential output, between the collector of A1Q7 and the collector of A1Q8. Figure 5-6 i and 5-6 j illustrates the waveform of the signal at the collector of A1Q8 and A1Q7 respectively.

4-102 The single ended sweep generator output at pin 7 of A1Q1C is applied to the base of A1Q7 through resistors A1R54 and A1R59. Transistor A1Q9 is connected as a constant current source and sinks 5.5 milliamperes to the -17 volt dc power supply. This current source is used to couple the sweep signal to the emitter of A1Q8 and therefore to supply a differential output from the collectors of A1Q7 and A1Q8. Resistors A1R58 and A1R68 form a differential feedback loop which limits and stabilizes the closed loop gain of A1Q7 and A1Q8. Potentiometer A1R60 is used to adjust the gain of the horizontal amplifier so that the trace will sweep approximately 10.5 major divisions in the horizontal direction. Capacitors A1C27, A1C33 and inductors A1L2 and A1L3 are used to extend the high frequency bandwidth of the horizontal amplifier. Potentiometer A1R81, adjustable from the rear porch of the oscilloscope module, is used to adjust the bias on the base of transistor A1Q8 via emitter follower A1Q10.

4-103 DETAILED CIRCUIT DESCRIPTION OF DISPLAY SECTION

4-104 A schematic diagram for the oscilloscope module is given in drawing E7510-070. Each module is designated at the A1 assembly. The display section of the oscilloscope module is divided into three sections. These are:

a) The Blanking Generator

b) The Focus Control

c) The Trace Angle Control

These sections of the oscilloscope module are described in detail in the following paragraphs of this publication.

4-105 THE BLANKING GENERATOR

4-106 The blanking generator consists of transistors A1Q5, A1Q6 and associated components connected so as to form a bistable multivibrator with emitter coupling. During the linear sweep period, transistor A1Q6 is biased to cut-off and the voltage at the control grid G1, of the CRT is controlled by A1R38, A1R45 and intensity (INTEN) potentiometer A1R40. During the retrace and hold-off time period, transistor A1Q6 is biased into saturation and the voltage at G1 of the CRT is driven more negatively so as to cut-off the CRT.

4-107 The input to the blanking generator is coupled from the output of the ramp control flip-flop, A1IC2D pin 13 via capacitor A1C13 to the base of A1Q5. At the start of the linear sweep period A1IC2D pin 13 is driven to the "1" state which produces a 3 volt positive going pulse at the base of A1Q5. This pulse causes A1Q5 to conduct which, in turn, drives the collector voltage of A1Q5 in the negative direction. This causes the emitter of A1Q6 to also move in the negative direction due to the voltage divider formed by A1R28 and A1R32. The emitter of A1Q5 is now biased more negatively than its base and, as a result, A1Q5 remains conduction after the positive going pulse through A1C13 has dissappeared. The base of A1Q6 is now biased more negatively than its emitter and, as a result, the collector cirucit of A1Q6 is turned "off".

4-108 At the end of the linear sweep A1IC2D pin 13 is driven to the "0" state which produces a 3 volt negative going pulse at the base of A1Q5. This pulse causes A1Q5 to instantly switch "off" which, in turn, drives the collector voltage of A1Q5 in the positive direction. This causes the emitter of A1Q6 to also move in the positive direction due to the voltage divider formed by A1R28 and A1R32. The emitter of A1Q5 is now biased more positively than its base and, as a result, A1Q5 remains cut-off after the negative going pulse through A1C13 has disappeared. The base of A1Q6 is now biased more positively than its emitter and, as a result, the collector circuit of A1Q6 is in saturation and the CRT is biased into cut-off.

4-109 THE FOCUS CONTROL

4-110 The focus (FOCUS) control consists of potentiometer A1R85 and associated components connected so as to form a voltage divider across the -1.976KV dc power supply. Potentiometer A1R85 controls the dc voltage to anode number 1, A1, of the CRT and is adjusted so as to provide a minimum, but constant, spot size over the entire useable face of the CRT. This focus voltage is normally between -1300 and -1500 volts dc for optimum spot size.

4-111 THE TRACE ANGLE CONTROL

4-112 The trace angle (TRACE ANGLE) control consists of potentiometer A1R83 and associated components connected so as to form a voltage divider across the +17 volt and -17volt dc power supplies. Potentiometer A1R83 varies the current through the trace angle control and thereby allows the trace to be rotated about the center of the face of the CRT. This allows the operator to manually adjust the display so as to compensate for CRT misalignment and effects of external static magnetic fields. The dc resistance of the trace angle coil is approximately 700 ohms.

4-113 DETAILED DESCRIPTION OF RACK ADAPTER/POWER SUPPLY

4-114 The power supply portion of the Model 7500 Monitor Oscilloscope is contained in the rear portion of the Model 7520 Rack Adapter/Power Supply. The power supply consists of two plug-in printed circuit boards, a power transformer and an innerconnect board which contains mating connectors A2J1 through A2J7 for all seven oscilloscope modules and mating connectors A2J8 and A2J9 for the plug-in power supply boards. All wiring between the plug-in power supply boards and the seven oscilloscope modules is a part of the innerconnect board, **assembly A2.**

4-115 Connectors J11 through J31, mounted on the rear of the rack adapter/ power supply, and floating from the rack adapter/power supply, are used to couple the REC, REP and EXT. TRIG. signals into the Model 7500 Monitor Oscilloscope System. These signals are transmitted through coaxial cable from the rear panel connectors to the oscilloscope modules in order to minimize electrical interactions.

4-116 THE TOP ASSEMBLY WIRING

4-117 A schematic diagram for the top assembly wiring of the Model 7520 Rack Adapter/Power Supply is shown in drawing D 7520-070. The three-conductor power cord is connected to the innerconnect board through a strain relief on the rear panel of the rack adapter/ power supply. The ground wire is connected directly to the chassis of the rack adapter/ power supply. The high side of the ac power input is connected to a low-pass filter, A2L1 and A2C1, through a fuse, A2F1 and the low side of the ac power input is connected to another low-pass filter, A2L2 and A2C2. These low-pass filters are used to remove high-frequency line noise which might interfere with proper operation of the oscilloscope vertical conditioning and sweep circuits. The output of the low-pass filter is used to drive the primary of the power transformer, T1 through the power switch, S1.

4-118 The primary winding of the power transformer T1 is split into two 115 volt sections which may be connected in parallel for operation from the 115 volt ac line or connected in series for operation from the 230 volt ac line. The dc resistance of each half of the primary winding of T1 is approximately 11 ohms.

4-119 THE LOW VOLTAGE POWER SUPPLY

4-120 A schematic diagram for the low voltage power supply is shown in drawing D7520-072 and is designated as the A4 assembly. The mechanical assembly for this printed circuit board is given in drawing D7520-702. The low voltage power supply contains all the rectifier and regulation circuitry required to provide the regulated +200 volt dc supply, the regulated +17 volt dc supply, the regulated +5 volt dc supply, and the regulated -17 volt dc supply for driving seven oscilloscope modules. Each power supply has a low output impedance to prevent module interaction from occurring via the power supply. Each power supply is also current limited to protect the supply in case of a short circuit on the output of the power supply.

4-121 THE +200 VOLT DC SUPPLY

4-122 The +200 volt dc supply consists of bridge rectifier A4CR1, filter capacitor A4C1, transistors A4Q1, A4Q2, integrated circuit A4IC1 and associated components connected so as to form a closed loop feedback type of regulated dc power supply. This supply provides +200 volts dc ±.5 per cent at 50 milliamperes dc with less than 10 millivolts peak-to-peak ripple.

4-123 Bridge rectifier A4CR1 rectifies the ac output from secondary S6 of transformer T1 and supplies approximately 275 volts dc to filter capacitor A4C1. Filter capacitor A4C1 reduces the ripple on the output of the bridge rectifier A4CR1 to less than 10 volts peak-to-peak at twice the incoming ac line frequency. Transistor A4Q1 is connected as a "series pass" transistor and is used to control the current flow from the capacitor A4C1 to the load on the output of the +200 volt dc supply. Transistor A4Q2 is connected in the emitter follower configuration and is used to supply the required base current to A4Q1.

4-124 Zener diodes A4CR5, A4CR8 and resistors A4R1, A4R2 are connected so as to form a pair of dc bias supplies, +210 volts and +180 volts, which are referenced to the +200 volt dc output. These two auxiliary power supplies are used to provide proper bias to the integrated circuit amplifier A4IC1.

4-125 Zener diode A4CR10 and resistors A4R8, A4R9, A4R10, A4R11, A4R12 form a bridge network which is driven from the +200 volt dc supply output. The difference between the dc voltage at the anode of A4CR10 and the dc voltage at the arm of A4R10 appears at the input to integrated circuit A4IC1 in the form of an error signal. This error signal is amplified by A4IC1 and is then used to drive the base of A4Q2 via resistor A4R4. If the output of the +200 volt supply should, for any reason, increase above 200 volts, then the dc voltage at pin 2 of A4IC1 would be greater than the dc voltage at pin 3 of A4IC1. This causes the output of A4IC1 at pin 6 to be driven in the negative direction. This, in turn, causes emitter followers A4Q1 and A4Q2 to also be driven in the negative direction until the output of the +200 volt dc supply returns to its original value.

4-126 Diodes A4CR6, A4CR7 and A4CR9, in conjunction with resistor A4R7 and emitter-base junctions of A4Q1 and A4Q2 function so as to limit the availiable base current to A4Q2 under overload conditions. This, in turn, limits the output current from the +200 volt dc supply to a safe value in case of excessive load or short circuit.

4-127 THE +17 VOLT DC SUPPLY

2-128 The +17 volt dc supply consists of bridge rectifier A4CR2, filter capacitor A4C2, integrated circuit A4IC2, transistor A4Q3 and associated components connected so as to form a closed-loop feedback type of regulated dc power supply. This supply provides +17 volts dc ±0.2 per cent at 500 milliamperes dc with less than 50 millivolts peak-to-peak ripple.

4-129 Bridge rectifier A4CR2 rectifies the ac output from secondary S4 of transformer T1 and supplies approximately 26 volts dc to filter capacitor A4C2. Filter capacitor A4C2 reduces the ripple on the output of the bridge rectifier to less than 2 volts peak-to-peak at twice the incoming line frequency. Transistor A4Q3 is connected as a "series pass" transistor and is used to control the current flow from the capacitor A4C2 to the load on the output of the +17 volt dc supply. Integrated circuit A4IC2 is a voltage regulator complete with dc reference, error amplifier and driver transistors. The voltage divider formed by A4R16, A4R17, A4R18 is used to supply a feedback signal into A4IC2. Potentiometer A4R17 is adjusted so as to set the output voltage of this supply to +17 volts dc. Resistor A4R13 and diode A4CR11 function so as to limit the base drive to A4Q3 under overload conditions, thereby protecting the +17 volt supply in case of excessive load or a short circuit.

4-130 THE +5 VOLT DC SUPPLY

4-131 The +5 volt dc supply consists of bridge rectifier A4CR4, filter capacitor A4C4, integrated circuit voltage regulator A4VR1 and associated components connected so as to provide +5.0 volts ±0.25 volts at 300 milliamperes dc with less than 10 millivolts peak-to-peak ripple

4-132 Bridge rectifier A4CR4 rectifies the ac output from secondary S7 of transformer T1 and supplies approximately +8.5 volts dc to filter capacitor A4C4. Filter capacitor A4C4 reduces the ripple on the output of the bridge rectifier to less than .5 volt peak-to-peak at twice the incoming ac line frequency. Integrated circuit voltage regulator A4VR1 is connected as a "series pass" regulator and is used to control the current flow from the capacitor A4C4 to the load on the output of the +5 volt dc supply. Capacitor A4C5 is used to by-pass pins 1 and 3 of the integrated circuit voltage regulator directly across the terminals of the integrated circuit in order to prevent possiable high-frequency oscillations in A4VR1.

4-133 THE -17 VOLT DC POWER SUPPLY

4-134 The -17 volt dc supply consists of bridge rectifier A4CR3, filter capacitor A4C3, integrated circuit A4IC3, transistor A4Q4 and associated components connected so as to form a closed-loop feedback type of regulated dc power supply. This supply provides -17 volts dc ±0.2 per cent at 500 milliamperes dc with less than 50 millivolt peak-to-peak ripple.

4-135 Bridge rectifier A4CR3 rectifies the ac output from secondary S5 of transformer T1 and supplies approximately 26 volts dc to filter capacitor A4C3. Filter capacitor A4C3 reduces the ripple on the output of the bridge rectifier A4CR3 to less than 2 volts peak-to-peak at twice the incoming ac line frequency. Transistor A4Q4 is connected as a "series pass" transistor and is used to control the current flow from the capacitor A4C3 to the load on the output of the -17 volt dc supply. Integrated circuit A4IC3 is a voltage regulator complete with dc reference, error amplifier and driver transistors. The voltage divider formed by A4R19, A4R20, A4R21 is used to supply a feedback signal into A4IC3. Potentiometer A4R20 is adjusted so as to set the output voltage of this supply to -17 volts dc. Resistor A4R14 and

diode A4CR12 function so as to limit the base drive to A4Q4 under overload conditions, thereby protecting the -17 volt supply in case of excessive load or a short circuit.

4-136 THE HIGH VOLTAGE POWER SUPPLY

4-137 A schematic diagram for the high voltage power supply is shown in drawing D7520-071 and is designated as the A3 assembly. The mechanical assembly for this printed circuit board is given in drawing D7520-701.

4-138 The high voltage power supply contains all the rectifiers and regulation circuitry required to provide the regulated -1976 volt, -2000 volt and -2050 volt dc output voltages for driving the seven oscilloscope modules. Each power supply has a low output impedance to prevent module interaction from occurring via the power supply. Each power supply is also current limited to protect the supply in case of a short circuit on the output of the power supply.

4-139 THE -2000 VOLT DC SUPPLY

4-140 The -2000 volt dc supply consists of a voltage doubler A3CR1, A3CR2, filter capacitors A3C1, A3C2, transistors A3Q2 through A3Q7 and associated components connected so as to form a closed-loop feedback type of regulated dc power supply. This supply provides -2000 volts dc ±1 per cent at 2 milliamperes dc with less than 2 volts peak-to-peak ripple.

4-141 Voltage doubler A3CR1 and A3CR2 rectifies the ac output (1000 volts ac) from secondary S1 and supplies approximately 2550 volts dc across capacitors A3C1 and A3C2 connected in series. Capacitors A3C1 and A3C2 reduce the ripple on the output of the voltage doubler to less than 60 volts peak-to-peak at twice the incoming ac line frequency. Transistor A3Q6 is connected as a "series pass" transistor and is used to control the current flow from the filter capacitors to the load on the output of the -2000 volt dc supply. Transistor A3Q7 is connected in the emitter follower configuration and is used to supply the required base current to A3Q6. Resistors A3R14, A3R15, A3R16 and A3R17 form a voltage divider between the regulated +200 volt dc supply and the output of the -2000 volt dc supply. The arm of potentiometer A3R15 is used to feed on the error signal back into the base of transistor A3Q7 and therefore to regulate the output of the -2000 volt dc supply. Transistors A3Q2, A3Q3, A3Q4, A3Q5 and bias resistors A3R2, A3R7, A3R9, A3R12, A3R13, A3R18, A3R22 are connected so as to form a voltage divider between the cathode of A3CR1 and circuit ground. This voltage divider functions so as to reduce the voltage available to the collector of A3Q6 during periods of overload or short circuit. Diodes A3CR8 and A3CR10, in conjunction with resistor A3R21 and emitter-base junction of A3Q6, function so as to limit the availiable base current to A3Q6 during overload or short circuit thereby protecting the -2000 volt dc supply in case of excessive load or short circuit. Resistors A3R23, A3R24, A3R25 and A3R26 conduct approximately 1 milliampere dc from ground to the -2000 volt output. This dc current is used to compensate for the dc current in the voltage divider string formed by A3R2, A3R7, A3R9, A3R12, A3R13, A3R18, and A3R22.

4-142 THE -2050 VOLT DC SUPPLY

4-143 The -2050 volt dc supply consists of a -50 volt dc supply referenced to the -2000 volt dc supply. The -50 volt portion of this supply consists of bridge rectifier A3CR3, filter capacitor A3C3, transistor A3Q1, zener diode A3CR4 and associated components connected so as to form a regulated dc power supply. This supply provides -50 volts dc ±5 per cent at 50 milliamperes dc with less than 150 millivolts peak-to-peak ripple.

4-144 Bridge rectifier A3CR3 rectifies the ac output from secondary S2 of transformer T1 and supplies approximately 62 volts dc to filter capacitor A3C3. Filter capacitor A3C3 reduces the ripple on the output of the bridge rectifier to less than 1.5 volts peak-to-peak at twice the incoming ac line frequency. Transistor A3Q1 is connected as a "series pass" transistor and is used to control the current flow from the capacitor A3C3 to the load on the output of the -50 volt dc supply. Zener diode A3CR4 provides a 51 volt reference for the base of A3Q1. Diodes A3CR5 and A3CR6, in conjunction with resistor A3R11 and the emitter-base junction of A3Q1, function so as to limit the availiable base current to A3Q1 under overload conditions. This, in turn, limits the output current from the -50 volt dc supply to a safe value in case of excessive load or short circuit.

4-145 THE -1976 VOLT DC SUPPLY

4-146 The -1976 volt dc supply consists of a 24 volt zener diode A3CR7 and filter capacitor A3C4 referenced to the -2000 volt dc supply and is used to supply beam current for each CRT as well as current for each focus divider on each module.

SECTION V

MAINTENANCE

5-1 GENERAL

5-2 Careful and regular performance of periodic preventive maintenance will will reduce the probability of failure and the need for corrective maintenance. Refer to figure 1-1, 3-1, 3-2, 5-2, 5-3 and 5-5 as aids in the performance of such maintenance.

5-3 TEST EQUIPMENT

5-4 The test equipment required for adjusting and troubleshooting the monitor oscilloscope is listed in table 1-2.

5-5 PREVENTIVE MAINTENANCE

5-6 INSPECTIONS. Perform periodic inspections as follows:

PERIOD	AREA OF INSPECTION	ITEMS TO BE CHECKED
Weekly	Exterior of unit, particularly front and rear	Controls, indicators, connectors, wiring, and hardware for dust and dirt, security of mounting or connection, and signs of damage.
Monthly	Interior of unit, including individual assemblies	Electrical parts and wiring, (including printed circuit wiring) for dust, dirt, corrosion, and evidence of overheating and other damage. Particular attention should be paid to remove dust from the high voltage power supply board and the high voltage sections of each oscilloscope module at the rear of the CRT and around the rear porch potentiometers.

5-7 CLEANING. Remove dust, dirt, and other foreign material using a small brush and vacuum cleaner. Low pressure air may be used if a vacuum cleaner is not available. When using the air, be sure to aim the air stream so that the foreign material will be blown away from the unit being cleaned, rather than into recesses, slot, etc. Use a cloth and a suitable solvent such as methyl-ethyl-ketone to remove material not removable by means of the above procedure.

CAUTION

Take care not to scratch the printed circuit wiring, if it is necessary to brush or rub it to remove foreign material. If solvent is used, allow all areas where solvent has been applied to thoroughly air-dry prior to placing in use.

5-8 LUBRICATION. No lubrication is required.

5-9 IN-RACK PERFORMANCE TEST

5-10 The in-rack performance test consist of removing normal input signals to the monitor oscilloscope and performing the preliminary tests contained in Section II of this publication.

5-11 TROUBLE SHOOTING

WARNING

HIGH VOLTAGE (2050 VDC)

This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied. Avoid contact with all input power connections, the high voltage power supply, and the high voltage sections of each oscilloscope module. Verify that these circuits have been grounded after power turnoff before touching.

5-12 Troubleshooting techniques normally used for oscilloscopes are appropriate for this equipment. High voltage sections of the power supply and of each oscilloscope module have been coated with 1B15 Humiseal and should be re-coated if repairs are made to these sections of the monitor oscilloscope. A schematic diagram for the low voltage power supply is given in drawing D 7520-072 and a schematic diagram for the high voltage power supply is given in drawing D 7520-071. The inner connection wiring diagram for the rack adapter/power supply is given in drawing D 7520-070. Since the power supply is common to all modules, it can be easily determined if the problem is in the power supply. If the problem is apparent in all modules, the problem is probably in the power supply. If the trouble is visible in only one module, the trouble is in that module or associated mating connector and wiring. Plug an operating module into the position of the defective unit to determine whether the trouble is in the module or in the associated mating connector and wiring.

5-13 TROUBLESHOOTING THE POWER SUPPLY WITH SEVEN OSCILLOSCOPE MODULES IN SYSTEM

5-14 Remove the power supply protective cover by first removing the six number 4 screws and washers located on top of the monitor oscilloscope and to the rear of the monitor oscilloscope. Table 5-1 gives voltages, tolerances and ripple levels for the power supply. All low voltages, less than 1000 volts dc are measured with the digital voltmeter. All high voltages, greater

Table 5-1. Power Supply Voltage Measurements.

All voltage measurements are made with nominal line voltage (either 115 volts or 230 volts, as applicable) 60Hz ac applied to the power input of the monitor oscillocope, seven modules in the oscilloscope, and with the TRACE switch in the "on" position. Connect the low side of the test equipment to A4TP2 on the low voltage power supply board, except as noted.

TYPE AND REFERENCE DESIGNATOR OF COMPONENT	TEST POSITION	VOLTAGE MEASUREMENT (DC VOLTS)	TOLERANCE (DC VOLTS)	RIPPLE VOLTAGE MEASUREMENT PEAK-TO-PEAK VOLTAGE
Bridge Rectifier A4CR4	plus side	8.5 volts dc	±1 volt dc	.5 volt maximum at twice ac line frequency
Integrated Circuit regulator A4VR1	+5V T.P.	5 volts dc	±0.25 volt dc	10 millivolts maximum at twice ac line frequency
Transistor A4Q4	collector	9 volts dc	±3 volts dc	2 volts maximum at twice ac line frequency
Filter Capacitor A4C3 (minus side)	-17V T.P.	-17 volts dc	±34 millivolts	50 millivolts maximum
Transistor A4Q4	emitter	+.25 volt dc	±0.05 volt dc	———
Potentiometer A4R20	arm	-15.4 volts dc	± .2 volt	———
Transistor A4Q3	collector	+26 volts dc	±3 volts	2 volts maximum at twice ac line frequency
Capacitor A4C14 (plus side)	+17V T.P.	+17 volts dc	±34 millivolts	50 millivolts maximum
Resistor A4R13	emitterof A4Q3 to +17V T.P.	+.25 volt dc	±0.05 volt dc	———
Potentiometer A4R17	arm	+1.6 volts	±0.2 volts dc	———

Table 5-1. Power Supply Voltage Measurements (Cont.).

TYPE AND REFERENCE DESIGNATOR OF COMPONENT	TEST POSITION	VOLTAGE MEASUREMENT (DC VOLTS)	TOLERANCE (DC VOLTS)	RIPPLE VOLTAGE MEASUREMENT PEAK-TO-PEAK VOLTAGE
Filter Capacitor A4C1 (plus side)	plus side	275 volts dc	±20 volts dc	10 volts maximum at twice ac line frequency
Capacitor A4C13 (plus side)	+200V T.P.	+200 volts dc	±1.0 volt dc	10 millivolts maximum
Transistor A4Q1	collector	260 volts dc	15 volts ±5 volts below plus side of A4C1	10 volts maximum at twice ac line frequency
Resistor A4R7	emitter of A4Q1 to +200V T.P.	+0.3 volts dc	±0.1 volt dc	———
Integrated Circuit A4IC1 to +200V T.P.	pin 6 of A4IC1 to +200V T.P.	-1.0 volts dc	±5.0 volts dc	———
Integrated Circuit A4IC1 to +200V T.P.	pin 2 of A4IC1 to +200V T.P.	-6.2 volts dc	±0.3 volts dc	———
Integrated Circuit A4IC1 to +200V T.P.	pin 3 of A4IC1 to +200V T.P.	-6.2 volts dc	±0.3 volts dc	———
Diode A3CR1 to A3CR2	cathode of A3CR1 to anode of A3CR2	2550 volts dc*	±100 volts dc	60 volts maximum at twice the incoming ac line frequency (Do not measure unless a 2KV scope probe is available)
Diode A3CR1	cathode	+550 volts dc	±100 volts	60 volts maximum at twice ac line frequency
Transistor A3Q2	collector	+350 volts dc	±50 volts	60 volts maximum at twice ac line frequency

Table 5-1. Power Supply Voltage Measurements (Cont.).

TYPE AND REFERENCE DESIGNATOR OF COMPONENT	TEST POSITION	VOLTAGE MEASUREMENT (DC VOLTS)	TOLERANCE (DC VOLTS)	RIPPLE VOLTAGE MEASUREMENT PEAK-TO-PEAK VOLTAGE
Transistor A3Q2	base	+290 volts dc	±50 volts	30 volts maximum at twice ac line frequency
Transistor A3Q3	base	+210 volts dc	±40 volts	25 volts maximum at twice ac line frequency
Transistor A3Q4	base	+130 volts dc	±20 volts	15 volts maximum at twice ac line frequency
Transistor A3Q5	base	+60 volts dc	±10 volts	8 volts at maximum at twice ac line frequency
Transistor A3Q6	emitter	+.12 volts dc	±0.03 volts dc	———
Transistor A3Q6	base	+.70 volts dc	±0.1 volt dc	———
Transistor A3Q7	base	+1.2 volts dc	±0.2 volts dc	———
Capacitor A3C6	-2KV T.P.	-2000 volts dc	±20 volts	2 volts maximum at ac line frequency (Do not measure unless 2KV scope probe is available)
Capacitor A3C4 to -2KV T.P.	-1.976KV T.P. to -2KV T.P.	+24 volts dc*	±2volts dc	Do not measure
Capacitor A3C5 to -2KV T.P.	-2.05KV T.P. to -2KV T.P.	-50 volts dc*	±2.5 volts dc	Do not measure

Table 5-1. Power Supply Voltage Measurements (Cont).

TYPE AND REFERENCE DESIGNATOR OF COMPONENT	TEST POSITION	VOLTAGE MEASUREMENT (DC VOLTS)	TOLERANCE (DC VOLTS)	RIPPLE VOLTAGE MEASUREMENT PEAK-TO-PEAK VOLTAGE
Capacitor A3C3 to -2.05KV T.P.	plus side of A3C3 to -2.05KV T.P.	+62 volts dc*	±5 volts dc	Do not measure
Diode A3CR4 to -2.05KV T.P.	cathode of A3CR4 to -2.05KV T.P.	+51 volts dc*	±2.5 volts dc	Do not measure

* Extreme care should be taken while making these measurements as measurement equipment is floating from ground and the low side of the test equipment is 2000 volts below ground potential.

than 1000 volts dc are measured with the high voltage probe connected to the digital voltmeter. All ripple voltages are measured with the oscilloscope. All floating measurements are made with the multimeter. If it is necessary to remove either the high voltage or low voltage board, then the two number 6 counter-sunk screws must be removed from the heatsink via the outside of the rack adapter/power supply. It is necessary to disassemble the two sections of the applicable rack slide in order to remove these screws. It is also necessary to remove the single number 4 screw used to support the rear of the power supply board.

5-15 TROUBLESHOOTING THE POWER SUPPLY WITHOUT OSCILLOSCOPE MODULES IN SYSTEM

5-16 In certain cases, it is desirable to troubleshoot the power supply without the oscilloscope modules in the system. In order for the regulated power supplies to operate properly it is necessary that they be loaded with at least two modules. The circuit, given in figure 5-1, shows the resistive load equivalent to seven oscilloscope modules and should be used as a load if the power supply is tested without the oscilloscope modules. The voltages and ripple levels, as given in table 5-1, also apply when the power supply is tested with the load circuit as given in figure 5-1.

5-17 POWER SUPPLY ADJUSTMENTS

5-18 Remove the power supply protective cover as was described in paragraph 5-14 of this publication. Load the output of the power supply with either seven oscilloscope modules or the load as given in figure 5-1. Turn the power supply "on", the TRACE "on", and allow a 30 minute warm-up period.

5-19 Figure 5-2 shows the location of all adjustments on the low-voltage power supply board. Figure 5-3 shows the location of all adjustments on the high-voltage power supply board.

5-20 With the low side of the differential voltmeter connected to A4TP2 and the high side connected to A4TP4, adjust A4R20 so that the -17 volt dc supply provides -17.00 volts ±10 millivolts.

5-21 With the low side of the differential voltmeter connected to A4TP2, and the high side connected to A4TP3, adjust A4R17 so that the +17 volt dc supply provides +17.00 volts ±10 millivolts.

5-22 With the low side of the differential voltmeter connected to A4TP2 and the high side connected to A4TP1, adjust A4R10 so that the +200 volt dc supply provides +200.0 volts ±0.2 volt.

5-23 With the low side of the digital voltmeter connected to A3TP2 and the high voltage probe for the digital voltmeter connected to A3TP3, adjust A3R15 so that the -2000 volt dc supply provides -2000 volts ± 2 volts.

5-24 LINE VOLTAGE AND INPUT POWER TEST.

5-25 Connect the ac power input of the monitor oscilloscope system in series with a variac and a wattmeter as shown in figure 5-4.

5-26 Apply ac power to the monitor oscilloscope system and allow a few minutes warm-up with the input line voltage adjusted to mid-line voltage (115 volts rms) with the variac. Turn the TRACE switch "on" and check that each module displays a horizontal sweep. The wattmeter should indicate approximately 75 watts.

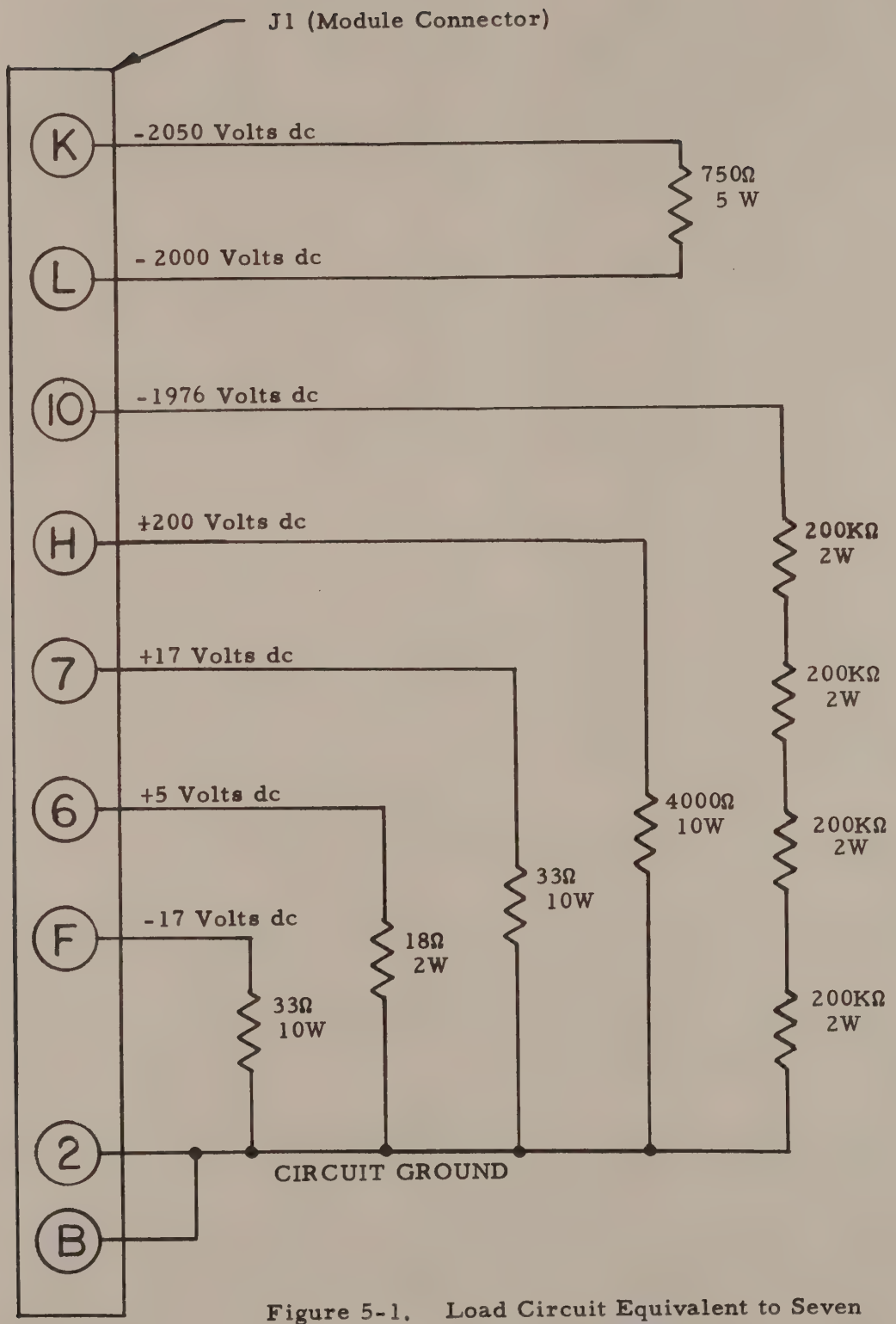


Figure 5-1. Load Circuit Equivalent to Seven Oscilloscope Modules.

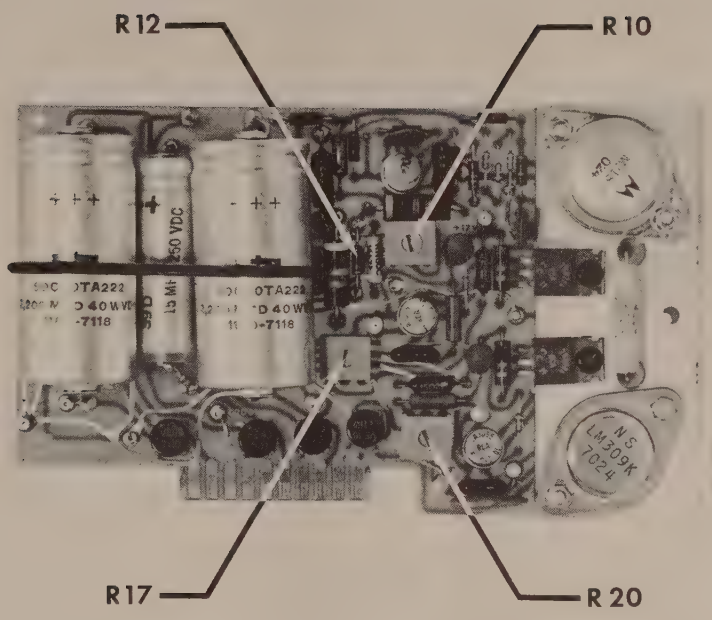


Figure 5-2. Low Voltage Power Supply.

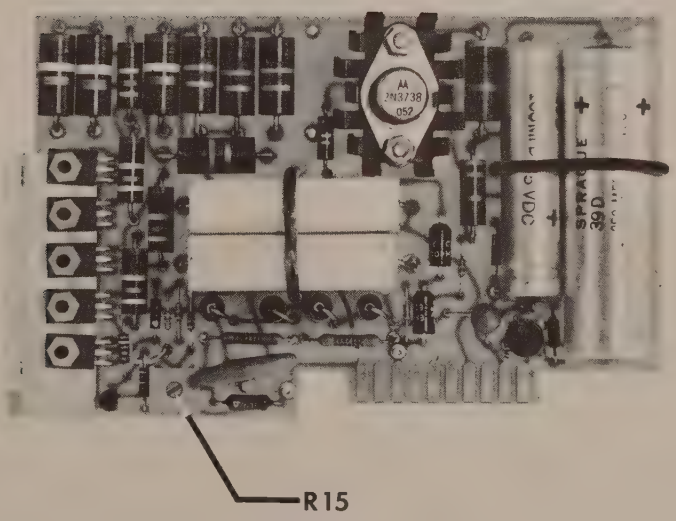


Figure 5-3. High Voltage Power Supply Board.

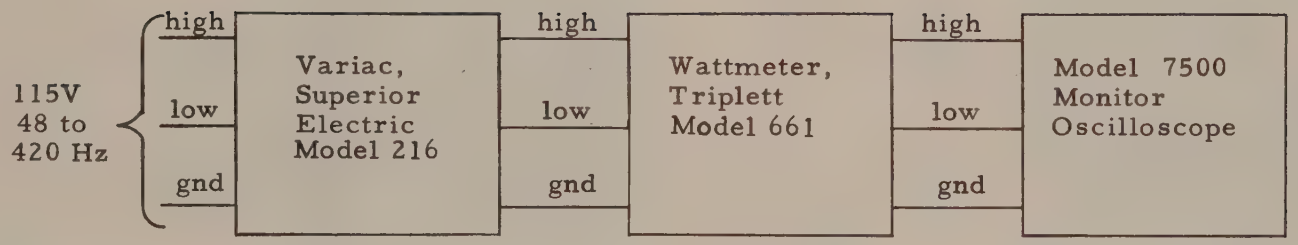


Figure 5-4. Test Circuit for Model 7500 Monitor Oscilloscope

5-27 Vary the line voltage from 105 volts to 125 volts while monitoring all oscilloscope power supplies under normal load. Table 5-2 below illustrates the maximum variation in each of the regulated power supplies for a change from 105 volts to 125 volts in the line voltage.

Table 5-2. Power Supply Regulation With Line Voltage Varied From 105 To 125 Volts Rms.

SUPPLY UNDER TEST	TEST POINT HIGH SIDE	TEST POINT LOW SIDE	MAXIMUM VARIATION IN DC OUTPUT FOR LINE VARIATION FROM 105 TO 125 VOLTS RMS
-17 volt	A4TP4	A4TP2	50 millivolts dc
+5 volt	A4TP5	A4TP2	25 millivolts dc
+17 volt	A4TP3	A4TP2	50 millivolts dc
+200 volt	A4TP1	A4TP2	250 millivolts dc
-2000 volt	A3TP3	A3TP2	5 volts dc
-2050 volt	A3TP5	A3TP3	2 volt dc *

* Extreme care should be taken while making this measurement as measurement equipment is floating from ground and low side of test equipment is 2000 volts below ground potential.

5-28 TROUBLESHOOTING THE OSCILLOSCOPE MODULE

5-29 In order to troubleshoot the oscilloscope module, the defective module should be extended outside the Model 7520 Pack Adapter/Power supply by means of the module extender assembly, part number 7510-701.

WARNING

HIGH VOLTAGE (2000 VDC)

This module contains potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied. Avoid contact with all input and output power connections. Special care should be taken to avoid high voltage sections of the oscilloscope module, including the rear panel focus control, intensity control, blanking circuits and horizontal amplifier circuits. Varify that these circuits have been grounded after power turn-off before touching.

5-30 It is often possible to troubleshoot the oscilloscope module by observing the waveform on the face of the CRT. Table 5-3 illustrates some common problems which can be determined from the oscilloscope display.

Table 5-3. Module Troubleshooting Chart.

SYMPTOM	PROBABLE CAUSE	ACTION
Horizontal trace on screen but no vertical signal on screen.	a) Check that vertical mode switch is in the correct position.	Rotate mode switch as required.
	b) Check vertical attenuator and attenuator switch.	Replace defective component.
	c) Check vertical amplifier.	Replace defective component.
Horizontal trace on screen and one-half of vertical signal.	Check vertical output stage A1Q12 and A1Q13.	Replace defective transistor.
Vertical signal present but no horizontal deflection.	a) Check the output of the sweep generator at collector of A1QIC pin 7.	Repair sweep generator.
	b) Check the output of the horizontal deflection amplifier at the collector of A1Q7 and A1Q8.	Replace defective component.
Vertical signal present but horizontal deflection extends only one-half way across screen.	Check horizontal output stage, A1Q7 and A1Q8.	Replace defective transistor.
Periodic short trace in the horizontal direction.	a) Check for arc in high voltage power supply or in high voltage section of oscilloscope module.	Replace defective component or clean high voltage board as required. Re-coat with Humiseal 1B15 as required.
	b) Check blanking generator.	Replace defective component.
Retrace line visible from end of trace back to start of trace.	a) Check blanking generator.	Replace defective component.
	b) Check -2050 volt supply.	Replace defective component.

Table 5-3. Module Troubleshooting Chart (Cont.)

SYMPTOM	PROBABLE CAUSE	ACTION
No presentation on the screen of the CRT regardless of control settings.	a) Check vertical amplifier.	Replace defective component.
	b) Check horizontal amplifier.	Replace defective component.
	c) Check blanking gererator.	Replace defective component.
	d) Check all high voltages supplies.	Replace defective component.
	e) Check filiment voltage to CRT.	Repair open circuit or replace defective power transformer.
	f) Check for CRT failure.	Replace CRT.

5-31 All operating voltages for the oscilloscope module are given in the schematic, drawing E7510-070 and should be used in conjunction with Table 5-3 in order to fully isolate a fault in the oscilloscope module. Critical waveforms for the oscilloscope module are shown in figure 5-6 and will further help to isolate a fault in the oscilloscope module.

5-32 OSCILLOSCOPE MODULE ADJUSTMENTS

5-33 Extend the module outside of the rack adapter/power supply by means of the module extender assembly as was described in paragraph 5-29.

WARNING

HIGH VOLTAGE (2000 VDC)

This module contains potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied. Avoid contact with all input and output power connections. Special care should be taken to avoid high voltage sections of the oscilloscope module, including the rear panel focus control, intensity control, blanking circuits. Varify that these circuits have been grounded after power turnoff before touching.

5-34 Check that all power supplies in the rack adapter/power supply are set to the correct value before attempting to adjust the oscilloscope module.

5-35 Figure 5-5 shows the location of all the adjustments on the oscilloscope module.

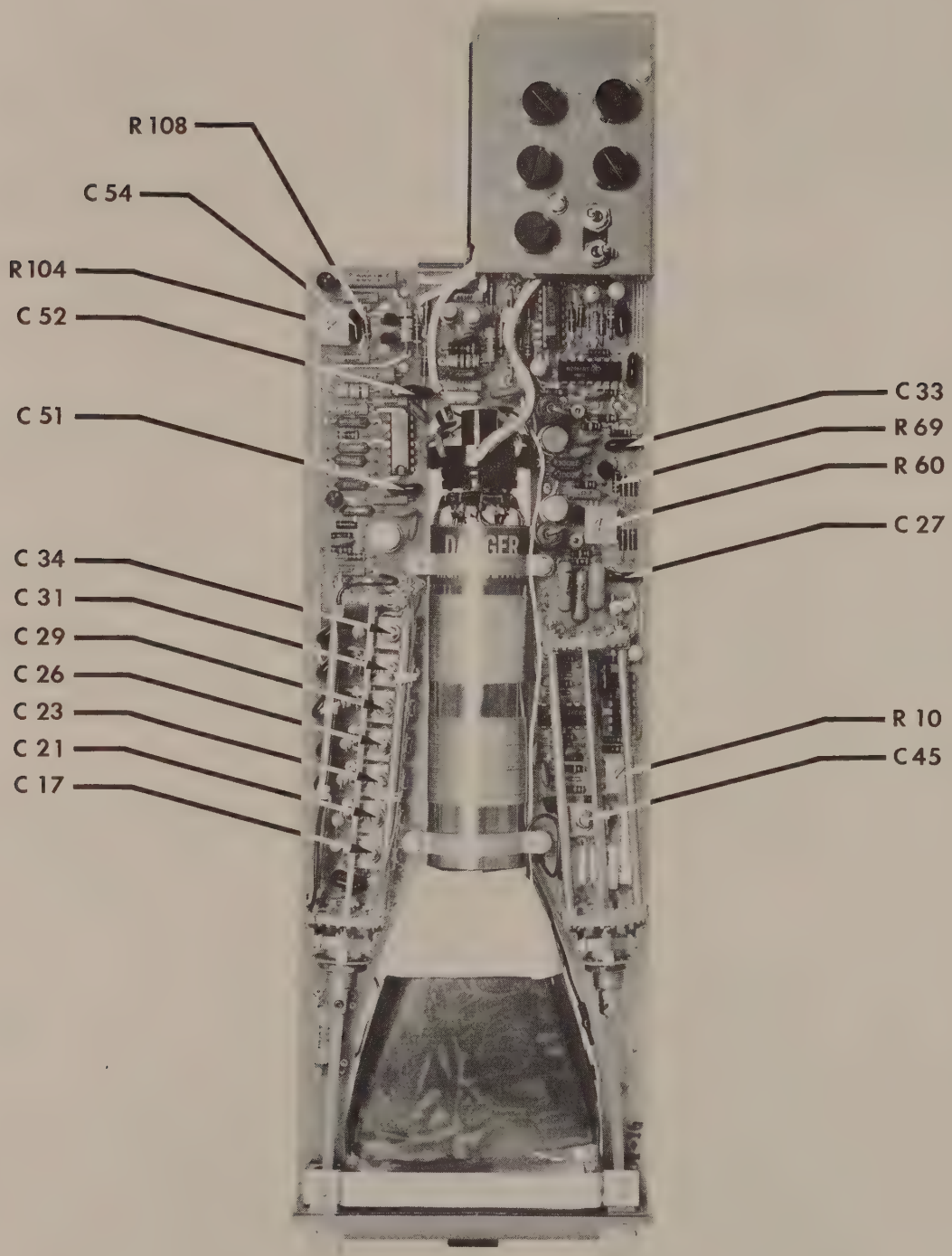
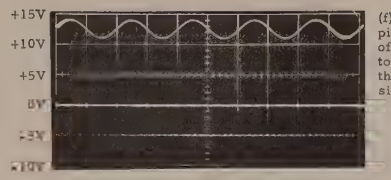
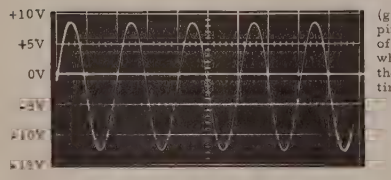


Figure 5-5. Location of Adjustments on the Model 7510 Oscilloscope Module.

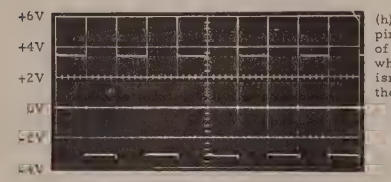
(a) Waveform at A1Q11B pin 5 showing the 250Hz vertical signal riding on a 12.5 volt dc level.



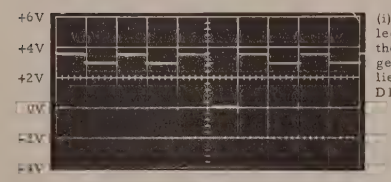
(b) Waveform at the collector of A1Q13 showing a 250Hz vertical signal riding on a -3 volt dc level as applied to deflection plate D3 of the CRT.



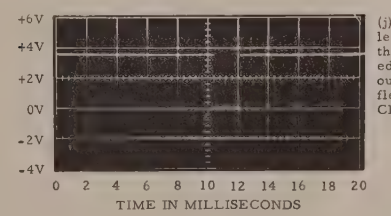
(c) Waveform at A1Q4E pin 14 showing the square wave output of the trigger amplifier in synchronism with the 250Hz vertical signal.



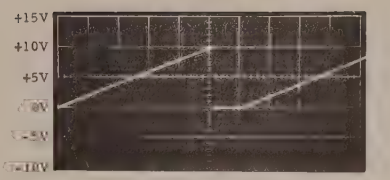
(d) Waveform at A1IC2 pin 1 showing the 3.5 volt positive going edge which triggers the ramp control flip-flop and starts a second linear



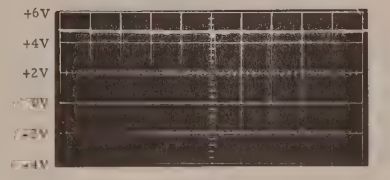
(e) Waveform at A1IC2 pin 13 showing the output of the ramp control flip-flop.



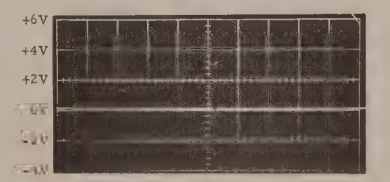
(f) Waveform at A1Q1C pin 7 showing the output of the time base generator in synchronism with the 250Hz veritcal input signal.



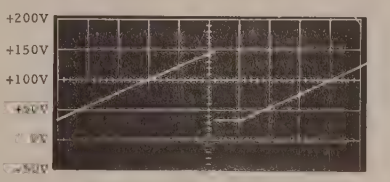
(g) Waveform at A1IC1A pin 8 showing the output of the level detector which is used to initiate the retrace and hold-off time period.



(h) Waveform at A1IC1A pin 1 showing the output of the hold-off generator which starts in synchronism with the output of the level detector.



(i) Waveform at the collector of A1Q8 showing the amplified time base generator output as applied to deflection plate D1 of the CRT.



(j) Waveform at the collector of A1Q7 showing the amplified and inverted time base generator output as applied to deflection plate D2 of the CRT.

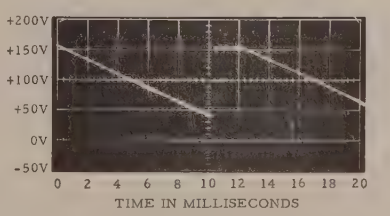


Figure 5-6. Waveforms of Critical Points in Model 7510 Oscilloscope Module.

All the above photographs were taken in such a fashion that all traces are in synchronism with one another. A 1.0 volt 250Hz signal was applied to the vertical input of the Model 7510 Oscilloscope Module with the VERT sensitivity control set to 1.0 volts rms per inch, the HORIZ sweep set to 0.1KHz, the VERN control in the calibrated position, the INT/EXT TRIG switch in the INT position, the +/- TRIG switch in the (+) position, and other rear porch controls set to provide a sharp display starting at the left hand side of the Model 7510 Monitor Oscilloscope Graticule and extending slightly past the right hand edge of this graticule.

5-36 SWEEP LENGTH ADJUSTMENT

5-37 Set the HORIZ sweep rate control to .01KHz and rotate the VERN control to the CAL position. Position the oscilloscope trace to the center of the screen and adjust the INTEN and FOCUS controls for a sharp trace. Adjust the TRACE ANGLE control to align the trace with the graticule. Adjust the sweep length with potentiometer A1R60 as required. If the range of the sweep potentiometer A1R60 is not sufficient then the value of resistor A1R69 may be changed.

5-38 Set the HORIZ sweep rate control to the .1KHz, 1KHz 10KHz, and 100 KHz ranges and check that the sweep length remains between 10 and 10.5 major divisions. If problems are encountered perform step 5-39 below.

5-39 Readjust potentiometer A1R60 so that the sweep length remains between 10 and 10.5 major divisions on all five sweep ranges.

5-40 HIGH FREQUENCY SWEEP LINEARITY

5-41 Set the VERT sensitivity to 1 volt rms per inch and apply a 1.0 volt rms 10.0 MHz sine wave to the applicable REC input located at the rear of the rack adapter/power supply. Select the DC-REC input channel as controlled by the vertical mode switch. Set the HORIZ sweep rate to 100 KHz and rotate the VERN control until the oscilloscope displays exactly ten cycles of the 10MHz sine wave in exactly ten major horizontal divisions.

5-42 Select capacitors A1C27 and A1C33 (about 50 pf each) so that the sweep linearity is within ±3 per cent and that the sweep length is between 10 and 10.5 major divisions.

5-43 SWEEP RATE CALIBRATION ADJUSTMENT

5-44 Select the DC-REC input mode as controlled by the REC/REP switch. Set the VERT sensitivity to 1.0 volt per inch and apply a 1.0 volts rms, 10 KHz sine wave to the applicable REC input located at the rear of the rack adapter/power supply. Monitor the output frequency of the sine wave oscillator with the counter and adjust the oscillator frequency to 10 KHz ±0.1 per cent.

5-45 Set the HORIZ sweep rate to 1 KHz and put the VERN control in the calibrated position. The oscilloscope should display exactly ten cycles ±.3 cycles of the 10 KHz sine wave in exactly ten major horizontal divisions. Potentiometer A1R10 may be adjusted if required.

5-46 Rotate the sweep VERN control fully clockwise. The oscilloscope display should show less than one cycle of the 10 KHz signal. Return the VERN control to the calibrated position.

5-47 Repeat paragraphs 5-44, 5-45 and 5-46 with the HORIZ sweep rate control settings as given in Table 5-4. Potentiometer A1R10 may be slightly readjusted for the best compromise on all of the four lowest HORIZ sweep ranges.

Table 5-4. Sweep Rate Adjustment Chart.

HORIZ SWEEP RATE SWITCH	FREQUENCY OF SINE WAVE GENERATOR
.01 KHz	100 Hz ±.1%
.1 KHz	1KHz ±.1%
10. KHz	100KHz ±.1%

5-48 Set the HORIZ sweep rate switch to 100 KHz and set the signal generator to 1.0 MHz as determined by the counter. The oscilloscope display should indicate ten cycles ±0.3 cycles of the 1 MHz sine wave in exactly ten major horizontal divisions. Capacitor A1C45 may be adjusted if required.

5-49 VERTICAL GAIN ADJUSTMENT

5-50 Set the HORIZ sweep rate to 10 KHz and rotate the VERN control to the calibrated position. Select the DC-REP switch and apply a 0.05 volt rms, 10 KHz sine wave signal into the applicable input at the rear of the rack adapter/power supply. Set the VERT sensitivity to .05 volt rms per inch. Adjust potentiometer A1R104 so that the trace on the oscilloscope module is exactly 4 major divisions in amplitude.

5-51 VERTICAL AMPLIFIER FREQUENCY RESPONSE ADJUSTMENT

5-52 Set the HORIZ sweep rate to 10 KHz and rotate the VERN control to the calibrated position. Select the AC-REC input mode as controlled by the front panel REC/REP switch and apply a 0.05 volt rms 50KHz sine wave signal from the Tektronix constant amplitude generator into the applicable REC input located at the rear of the rack adapter/power supply. The oscilloscope should display approximately five cycles of the 50 KHz input signal and the peak- to-peak amplitude should be 4.0 major divisions.

5-53 Increase the frequency of the constant amplitude generator to 10 MHz in small increments. The peak-to-peak amplitude of the display on the screen of the oscilloscope should remain between 3.8 and 4.2 major divisions to 5 MHz and should remain between 2.8 and 5.2 major divisions to 10 MHz. Trim capacitors A1C51, A1C52, A1C54 and resistor R111 may be changed, if required. However, this is not normally necessary as they have been pre-set at the factory. If a change in the value of these components is required then it is best to start with A1C54 and R111 if the problem is in the 5 to 10 MHz region. If the problem occurs at a lower frequency probably the value of all three capacitors will have to be changed. If these components are modified, then it will be necessary to re-check the vertical gain adjustment given in paragraph 5-50 of this publication.

5-54 VERTICAL ATTENUATOR ADJUSTMENT

5-55 The vertical attenuator is used on the 0.1 volt per inch through 10 volt per inch sensitivity ranges of the oscilloscope module. It is necessary to adjust the vertical amplifier, as given in paragraph 5-52 and 5-53 of this publication, before proceeding to the adjustment of the vertical attenuator.

5-56 Set the VERT sensitivity to 0.1 volt rms per inch and apply a .212 volt peak-to-peak, 5KHz square wave to the DC-REC input of the applicable oscilloscope module. Select the DC-REC input to the module under test. Set the HORIZ sweep rate to 1.0KHz and adjust the VERN control until the oscilloscope displays approximately two cycles of the 5KHz square wave. The peak-to-peak amplitude should be approximately three major divisions. Adjust capacitor A1C17 so that the square wave exhibits a flat top with a minimum of peaking or droop at the leading edge.

5-57 Repeat paragraph 5-56 for the remaining VERT sensitivity positions. Use the following input signals and adjust the appropriate capacitor as indicated in Table 5-5 below so that the square wave exhibits a minimum of peaking or droop at the leading edge.

Table 5-5. Adjustment of Vertical Attenuator.

VERT SENSITIVITY	AMPLITUDE OF 5 KHz SQUARE WAVE	ADJUST VARIABLE CAPACITOR
0.2 volt	.424 volts peak-to-peak	A1C21
0.5 volt	1.06 volts peak-to-peak	A1C23
1.0 volt	2.12 volts peak-to-peak	A1C26
2.0 volt	4.24 volts peak-to-peak	A1C29
5.0 volt	10.6 volts peak-to-peak	A1C31
10 volt	21.2 volts peak-to-peak	A1C34

5-58 ADDITIONAL OSCILLOSCOPE MODULE TESTS

5-59 The tests given in Table 5-6 should be performed to insure that the oscilloscope module is operating properly. No internal adjustments on the module are provided during these tests and if problems are encountered, they should be fixed by conventional servicing techniques applicable for oscilloscopes.

Table 5-6. Additional Oscilloscope Module Tests.

TEST	FUNCTION	TEST METHOD
1. REC/REP Input Test	To verify operation of the REC/REP switch and signal input wiring in the rack adapter/ power supply.	a) Select the AC-REP input as controlled by the front panel REC/REP switch. b) Set the VERN sensitivity to 2.0 volt rms per inch and apply a 1.0 volt rms 10 KHz sine wave in series with a 1.5 volt battery into the applicable REP input located at the rear of the rack adapter/power supply. c) Set the HORIZ sweep rate to 1 KHz and put the VERN control in the calibrated position. The oscilloscope should display ten cycles of the 10 KHz input signal with a peak-to-peak amplitude of 2.0 major division. d) Select each of the GND positions on each oscilloscope module and check that the vertical component of the display goes to zero as the mode switch is placed in the GND position. e) Select the DC-REP input as controlled by the front panel REC-REP switch. The vertical position of the display should change upward approximately 1.0 major division. f) Repeat for all seven channels of the monitor oscilloscope. g) Select the AC-REC input as controlled by the front panel REC-REP switch and apply the composite ac-dc input signal to the applicable REC input located at the rear of the rack adapter/power supply. Repeat steps (d) and (e) for all seven channels of the monitor oscilloscope.

Table 5-6. Additional Oscilloscope Module Tests (Cont).

TEST	FUNCTION	TEST METHOD
2. Trigger Slope Polarity Test	To verify operation of the trigger slope polarity switch on the rear porch of each oscilloscope module.	a) Select the AC-REC input and set the HORIZ sweep rate to 1 KHz and put the VERN control in the calibrated position. Set the VERT sensitivity to 1.0 volt rms per inch and apply a 1.0 volt rms 10 KHz sine wave input to the applicable REC input located at the rear of the rack adapter/power supply. Set the rear porch INT/EXT TRIG switch to the internal position. b) Select the positive (+) TRIG polarity and check that the initial slope of the left hand cycle displayed on the oscilloscope is positive. Select the negative (-) TRIG polarity and check that the initial slope of the left hand cycle displayed on the oscilloscope is negative. c) Repeat step (a) and step (b) for all seven oscilloscope modules.
3. Internal/External Trigger Test	To verify operation of the INT/EXT TRIG switch on the rear porch and the external trigger input wiring in the rack adapter/power supply.	a) Apply a .15 volt peak-to-peak, 10 KHz input to the applicable EXT TRIG input at the rear of the rack adapter/power supply. Apply the same signal to the applicable REC input at the rear of the rack adapter/power supply. b) Select the AC REC input and set the HORIZ sweep rate to 1 KHz and put the VERN control in the calibrated position. Set the VERT sensitivity to 0.2 volt rms per inch. c) Select the EXT TRIG position with the rear porch control. The oscilloscope module time base should be synchronized with the vertical signal. Remove the EXT TRIG input but retain the vertical signal into the module. The oscilloscope vertical signal should immediately go out of synchronism with the time base. d) Repeat step (a) through step (c) for all seven oscilloscope modules.

Table 5-6. Additional Oscilloscope Module Tests (Cont).

TEST	FUNCTION	TEST METHOD
4. Internal Trigger sensitivity test	To verify the trigger sensitivity with an internal trigger signal.	a) Select the DC-REC input and apply a 5 millivolt, 100 Hz input to the applicable REC input located at the rear of the rack adapter/power supply. Set the VERT sensitivity control to .05 volts rms per inch and set the HORIZ sweep to 0.01 KHz. Select the negative (-) TRIG polarity and put the VERN control in the calibrated position. b) Check that the display shows 10 cycles of the 100 Hz signal with a peak-to-peak amplitude of two minor divisions. Slowly vary the VERN control from the fully counter clockwise position to the fully clockwise position. The verical signal should remain syncronized with the time base for all positions of the VERN control. d) Increase the HORIZ sweep speed and the vertical input signal in decade steps and vary the VERN control while simultaneously checking that the vertical signal remains synchronized with the horizontal time base. Maintain the vertical input signal at such a level as to provide a peak-to-peak vertical deflection of 2 minor divisions. A small increase in the trace width may be seen on the 100 KHz sweep range due to slight variations in the starting point of the linear sweep. e) Set the HORIZ sweep to 100 KHz and set the VERN control fully clockwise. Vary the frequency of the vertical input signal from 1 MHz to 10 Mhz while maintaining the amplitude of the vertical deflection at 2 minor divisions. The vertcial signal should remain synchronized with the horizontal time base however a small increase in the trace width will be seen due to slight variations in the starting point of the linear sweep. f) Repeat steps (a) through (e) for all seven oscilloscope modules.

Table 5-6. Additional Oscilloscope Module Tests (Cont).

TEST	FUNCTION	TEST METHOD
5. External trigger sensitivity test	To verify the trigger sensitivity with an external trigger signal	a) Select the DC-REC input and apply a 150 millivolt peak-to-peak 50 Hz signal to both the applicable EXT TRIG input and the REC input located at the rear of the rack adapter/power supply. Set the VERT sensitivity to 0.05 volts rms per inch and set the HORIZ sweep to 0.01KHz. Select the negative (-) TRIG polarity and select the EXT TRIG mode of operation with the switches located on the rear porch of the oscilloscope module. Slowly vary the VERN control from the fully counter clockwise position to the fully clockwise position while checking that the vertical signal remains synchronized with the horizontal time base. b) Repeat step (a) except set the EXT TRIG input signal to 150 millivolts peak-to-peak at 1 MHz and set the HORIZ sweep to 100 KHz. c) Repeat step (a) except set the EXT TRIG input signal to 0.5 volts peak-to-peak at 10 MHz and set the HORIZ sweep to 100 KHz. d) Repeat step (a) except set the EXT TRIG input signal to 0.5 volts peak-to-peak at 10 Hz and set the HORIZ sweep to .01 KHz. e) Repeat steps (a) through (d) for all seven oscilloscope modules

Table 5-6. Additional Oscilloscope Module Test (Cont).

TEST	FUNCTION	TEST METHOD
6. Vertical amplifier transient response.	To verify the transient response of the vertical deflection system to a transient with a fast rise time.	a) Select the DC-REC input and connect a 50 ohm feed-through termination unit directly to the applicable REC input at the rear of the rack adapter/power supply. Connect the 50 ohm output of the pulse generator to the 50 ohm termination via a 2 to 3 foot section of RG58U coaxial cable. b) Set the VERT sensitivity of the oscilloscope module to 5 volts rms per inch and set the pulse generator so as to provide a positive going pulse with a 5 volt peak-to-peak amplitude. c) Select the positive (+) TRIG polarity and select the EXT TRIG mode of operation with the switches located on the rear porch of the oscilloscope module. Connect the advanced trigger output of the pulse generator to the applicable EXT TRIG input on the rear of the rack adapter/power supply via coxial cable terminated in a 50 ohm termination unit. d) Set the HORIZ sweep to 100 KHz and the VERN control so as to provide a 1MHz sweep (100 nanoseconds per major division). e) Set the pulse generator output so as to provide a 10 microsecond pulse with a 10KHz to 20KHz repetation rate. Set the time delay of the pulse generator such that the positive going output of the pulse generator is displayed in the center of the oscilloscope display. Set the VERT position of the oscilloscope module so that the base line is one major division above the bottom of the CRT. The 0 to 90 per cent rise time of this pulse should not exceed 40 nanoseconds . A small amount of ringing may also exist on the oscilloscope display after the 40 nanosecond rise time period.

Table 5-6. Additional Oscilloscope Module Tests Cont.

TEST	FUNCTION	TEST METHOD
		f) This test may be repeated on other VERT sensitivity ranges of the module, if desired. Care should be taken so as to limit the vertical amplitude of the signal to two major divisions so as to prevent possible slew rate limitations. g) Steps (a) through (f) may be repeated for all seven oscilloscope modules, if desired.
7. Vertical amplifier DC drift	To verify the dc drift performance of the vertical amplifier	a) Select the GND position of the seven oscilloscope modules and set the HORIZ sweep of all seven modules to the 0.01 KHz sweep position. Set the VERN control of all seven modules to the calibrated position and allow the unit to warm up for one-half hour in a 25°C environment. b) Check that the trace on all seven oscilloscope modules are aligned with the center graticule line. Position the trace, as required, by use of the VERT position control. c) Increase the ambient temperature to 55°C and allow the oscilloscope system to stabilize for one-half hour. The oscilloscope trace on each module should move less than one-half minor division in the vertical direction.

SECTION VI

CIRCUIT DIAGRAMS

6-1 GENERAL

6-2 This section contains schematics and mechanical diagrams necessary for operation and maintenance of the Model 7500 Monitor Oscilloscope. The schematic diagrams illustrate the circuit while the mechanical assemblies indicate the part placement.

6-3 REFERENCE DESIGNATIONS

6-4 Partial reference designators are shown on schematic and mechanical drawings. Prefix these reference designators with assembly and/or sub-assembly designation for the complete reference designator. For example;

Assembly/Sub-Assembly	Component	Component Designation
A1	C2	A1C2
None	T1	T1
A3	C1	A3C1
A4	R1	A4R1

SECTION VII

REPLACEABLE PARTS

7-1 GENERAL

7-2 This section contains ordering information and complete list of replaceable parts. Parts are listed by major assembly in alpha-numerical order of their reference designators. Description, manufacturers' part number, manufacturers' code ident number (see Appendix A for list of manufacturers), and CALIFORNIA INSTRUMENTS stock numbers are indicated.

7-3 ORDERING INFORMATION

7-4 In order to provide our customers with prompt service on replacement parts, please provide the following information, when applicable, for each part ordered:

a) Model number and serial number of the instrument,

b) CALIFORNIA INSTRUMENTS part number of the sub-assembly where component is located,

c) Component reference designator,

d) Component description,

e) Component manufacturer's number and code ident,

f) CALIFORNIA INSTRUMENTS stock number.

All replacement parts orders should be placed with CALIFORNIA INSTRUMENTS, A Norlin Technology Company, San Diego, California, 92111.

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